Vol. 19 MARCH 1946 No. 3

Instruments

THE MAGAZINE OF Measurement and Control

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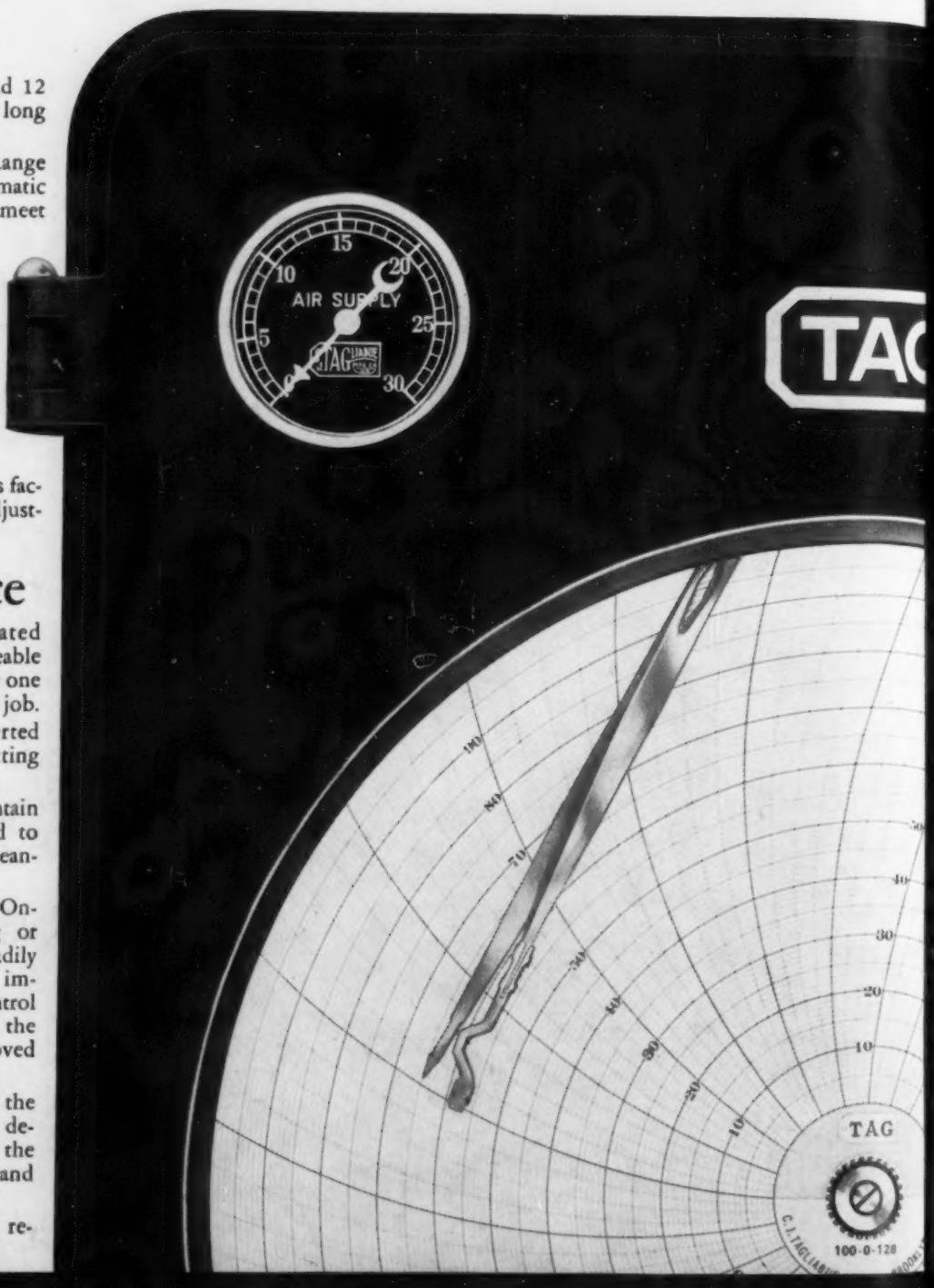

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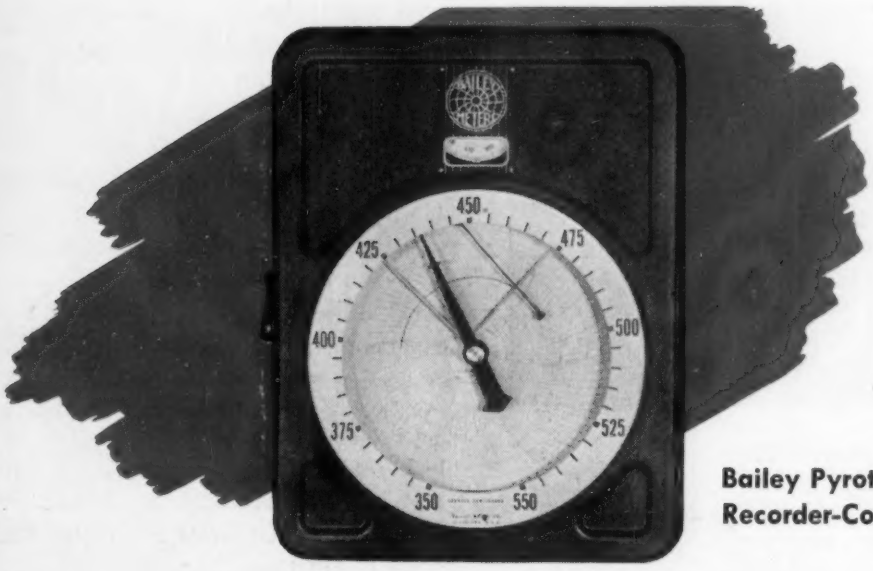

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ABUNDANT POWER

A separate motor drive for each temperature furnishes abundant power to operate a recording pen, a controller and an alarm switch.

For the full story on this unusual electronic resistance thermometer which is suitable for ranges between —100°F and 1200°F, ask for Bulletin No. 230-A. P-9

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TEMPERATURE	FLOW
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Instruments
THE MAGAZINE OF
Measurement and Control

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DISTRICT OFFICES AND MANAGERS
Boston 14: James Condon, 36 Myrtle St., Telephone Lafayette 0829
Cleveland 14: C. Goldcamp, 859 Leader Bldg., Cherry 2261
New York 17: R. K. Farnham, Room 615, 17 East 42nd St., Telephone Murray Hill 2-0821.
Chicago 1: Harold W. Haskett, Room 615, 360 N. Michigan Ave., Telephone Andover 4299
Cincinnati 2: Harold W. Haskett, Keith Bldg., Telephone Main 4260
St. Louis 1: James R. Wright, 915 Olive St., Telephone Chestnut 1965
Pasadena 1: M. D. Pugh, 35 S. Raymond Ave., Telephone Ryan 1-6510
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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

An Unusual Thermometric Problem

EVERY month lurks the temptation to print subscribers' inquiries and our answers. Laziness whispers that it saves the toil of writing a good editorial; vanity insinuates that our letters make interesting reading. Today, March slithers in like a voluptuous temptress: a cloudless sky and a balmy 70°. We succumb! Here is the latest from the Inquiry-and-Answer department:

THE INQUIRY [on a postal card]

. . . What kind of wires to use in a thermocouple that will react to 1/100 degree C. measurement on Weston galvanometer? . . . —AHP

OUR REPLY

Surely you do not desire to engage in research on untried thermoelements; therefore we assume that you desire information on *commercially-available* thermocouples. Of these, the chromel-constantan develops an average of about 75 microvolts per degree C., the iron-constantan about 60 and the chromel-alumel about 40. Thus, the *change* in emf. for a 1/100°C. change in the measured temperature is a fraction of a microvolt. You do not mention what model of Weston galvanometer you are using, but obviously it should be capable of responding to tenths (or fiftieths) of microvolts.

This, however, is only the beginning if your problem is to *measure* temperatures with an uncertainty less than 1/100°C. Whatever kind of a measuring system you assemble, it will have to be calibrated against a Standard Thermometer which will have to have a guaranteed accuracy of 1/1000°C. as evidenced by a recently-issued Certificate from the National Bureau of Standards or from the manufacturer.

Instead of trying to assemble such a thermoelectric measuring system of your own, why not buy one (accompanied by a Certificate) from a manufacturer whose research and development men have already solved the problems facing you?

And, instead of deciding on the thermocouple method, why not consider the resistance method, which Professor Langley sixty years ago used in detecting temperature changes of a millionth of a degree? Again, if you decide on the resistance method, we recommend that you order the equipment from an instrument company which has already solved the problems and which can guarantee not merely *sensitivity* but *accuracy.* —MFB

SUPPLETORY INQUIRY

. . . Where can I purchase a Langley Bolometer that will register 1/100° change in the skin temperature over a nerve before and after a Chiropractic adjustment of the spine? . . . —AHP

SUPPLETORY REPLY

I had mentioned Langley's 1886 achievements to "sell" the resistance METHOD—not the bolometer in particular (which is a radiometer chiefly used for infrared spectrometry). Your postal card had mentioned neither your occupation nor the intended application. Now your letter states that your "application" is a tiny area of human skin; and that you desire to measure not the temperature but the temperature change.

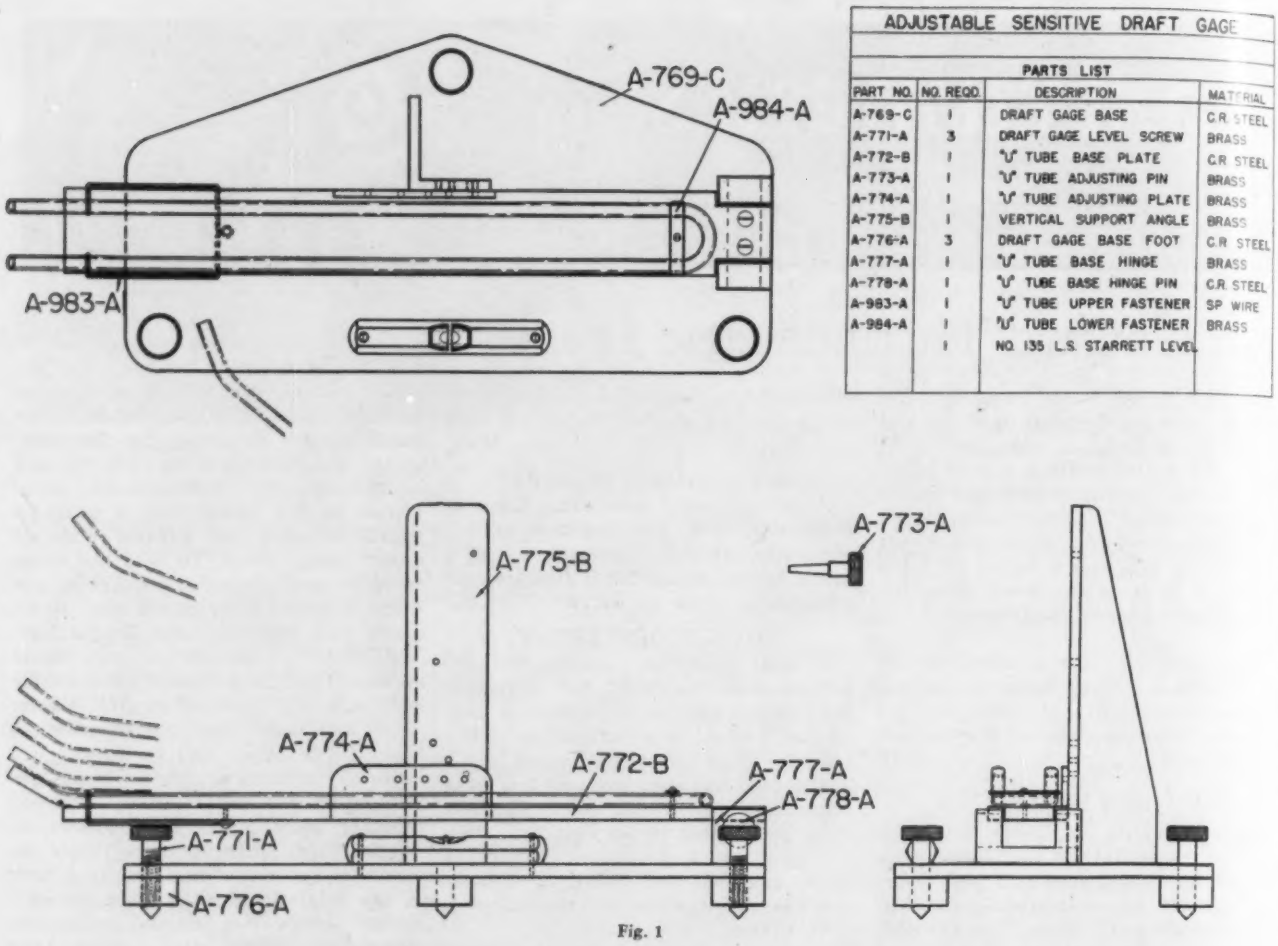
These two conditions are closely interrelated with respect to possible solutions of your problem:

(1) If your only requirement were to measure the temperature of the area over a single nerve-end, say 1/16" square, without discomfort to the patient, several instrument companies could supply you with duplicates of the thermoelectric or resistance elements they supplied to Doctors DuBois, Warren, Bishop, Bazett, Hardy, Oppel, Jenkins, Herrington, Gagge, Burton, McGlone, Brocklehurst, Hardy and other investigators in this fascinating field.

(2) Your second requirement is to measure an *exceptionally rapid* change. This I must assume because you specify 1/100°C. and because changes of the order of 1/100° in 15 seconds or less are normal, especially after meals or during any physical treatment whether good or bad for the patient. Therefore I must assume that the Chiropractic adjustment takes place in a small fraction of a second, for otherwise the random temperature changes due to miscellaneous causes would completely mask the change due to the adjustment. Therefore the element must not only weigh much less than a 1/16" square of epidermis (so that *its* temperature will not slow down the rapid change to be studied) but it must have a negligible lag coefficient so that it will faithfully respond to the rapid change. The ruggedly-built industrial forms of resistance elements are unsuitable: perhaps a thousand times too heavy. And the actual element (sensitive area) of a bolometer would be too long. The first solution of this problem that comes to my mind is an 1/8" square of cigarette paper as the mounting for the "element" and its lead wires; the element being a line 1/32" wide and 1/16" long, drawn on the paper with a graphite pencil between the parallel ends of 0.001" silver wires. To hold the wires in place and protect the graphite element against perspiration and wear, apply "Sargent's Picture Mastic Varnish" with an atomizer as you would to an oil painting. Back this assembly with a 1/4"x1/2" piece of surgical plaster or Scotch tape. Bend the silver wires around the edges and on to the dry side; solder them to two ordinary copper wires and secure these joints by another piece of surgical plaster or Scotch tape. Make up ten of these assemblies (or better ones resulting from a few trials) and send them for *individual calibration* to an instrument company—preferably the company from which you will obtain the amplifier, resistance bridge and other necessary components. I shall print this in *Instruments* and in *The Instrument Maker* in the hope that readers who have solved similar problems will contribute better suggestions than mine. For example, graphite has a low temperature coefficient of resistivity and perhaps someone knows how to make a duodecatomic-thickness "surface element" of bismuth or magnesium or other high-coefficient material.

Your measuring apparatus must be correspondingly fast. A galvanometer designed for 1-microvolt full-scale deflection would probably have a period of several seconds and its pointer or light-spot would be beginning to swing after your experiment would be over. It seems to me that the requisite instrumentation should include an amplifier and a rapid recorder—like an electroencephalography outfit. —MFB

P. S. You may wonder why I don't recommend an element in the form of a bare fine-wire thermocouple as used by some of the medical research men I named. The reasons are: (1) For 1/100°C. work, the reference-junction temperature must be kept to ± 1/500° and one must KNOW that it stays that way; (2) for 1/100° work the whole circuit becomes such a delicate job that, as we say, "a red-headed gal looking at binding-post No. 7 will make the pen shoot off-scale." —MFB



ADJUSTABLE SENSITIVE DRAFT GAGE

PARTS LIST

PART NO.	NO. REQD.	DESCRIPTION	MATERIAL
A-769-C	1	DRAFT GAGE BASE	C.R. STEEL
A-771-A	3	DRAFT GAGE LEVEL SCREW	BRASS
A-772-B	1	"U" TUBE BASE PLATE	C.R. STEEL
A-773-A	1	"U" TUBE ADJUSTING PIN	BRASS
A-774-A	1	"U" TUBE ADJUSTING PLATE	BRASS
A-775-B	1	VERTICAL SUPPORT ANGLE	BRASS
A-776-A	3	DRAFT GAGE BASE FOOT	C.R. STEEL
A-777-A	1	"U" TUBE BASE HINGE	BRASS
A-778-A	1	"U" TUBE BASE HINGE PIN	C.R. STEEL
A-983-A	1	"U" TUBE UPPER FASTENER	SP. WIRE
A-984-A	1	"U" TUBE LOWER FASTENER	BRASS
	1	NO. 135 L.S. STARRETT LEVEL	

Fig. 1

An Adjustable-range Sensitive Draft Gage

By H. MAURICE CARLSON, Battelle Memorial Institute, Columbus 1, Ohio

ALTHOUGH several inclined-tube draft gages are available with which small differences of pressure can be accurately measured, each usually has but one range and one degree of precision. In a combustion research laboratory, where the range of pressure differences to be measured may vary widely, there is need for a gage whose range and sensitivity can be quickly adjusted to various required values.

For some years at Battelle, a modification of the gage first designed about 1915 by Henry Kreisinger,[1] then of the U. S. Bureau of Mines, has been used. The inclination of the U-tube in that gage was continuously variable throughout its range and, by means of a thumbscrew, it could be locked in position. Positions were indicated by reference hairlines. At the minimum angle, particularly, a slight error in matching the index lines led to a large percentage-error in the readings.

Recently, the design has been so modified that each setting is fixed by a tapered pin through a movable plate and fixed support member. Assuming proper leveling, the accuracy of the gage at any time will thus equal that of the initial calibration.

The instrument, as made, has five ranges permitting reading of a maximum pressure difference of 0.2" to 5" of water. The smallest scale divisions equal 0.001" to 0.025" of water.

Construction

Only simple machine-shop equipment is required for making the gage. Fig. 1 shows the details of construction; Fig. 2 is a photograph of the assembled instrument. Few dimensions are given, as they are not critical and can be as required for the purpose at hand.

The base (A-769-C) is made of a piece of cold-rolled plate ¼" thick, shaped as indicated in the drawing. This base is supported by three screws which serve to level the instrument in two directions. Longitudinal leveling is accomplished by adjusting the two screws at either end of the gage; the level is indicated by the level fixed to the base. Lateral leveling is accomplished by adjusting the screw at the back of the gage until the position of the liquid level is the same in both legs of the U-tube when no source of pressure difference is connected to the gage.

The Pyrex glass tube, which forms the measuring element, rests upon a piece of ¼" cold-rolled steel, 1½" wide (A-772-B). One end of this tube base is pivoted to the instrument base plate. To insure accuracy of draft measurements, it is essential that the centerline of the pivot pin (A-778-A) be exactly parallel to the surface of the instrument base plate, so that the inclining-tube base will follow the vertical support member (A-775-B) when the inclination is changed. This vertical support member is made of a ¼" brass angle so machined that the vertical face, which serves to guide and support the inclined tube, is at 90° to the surface of the instrument base. This is essential in order to allow the vertical face to maintain contact with the inclined-tube base as the latter is moved from position to position.

The various positions or settings for this gage, indicated by the five bent tube ends shown on the drawing, are ob-

(1) G. A. Bole, John Blizard, W. E. Rice, E. P. Ogden and R. A. Sherman. "Problems in Firing Refractories," *U. S. Bureau of Mines Bulletin No. 271*, 1927, page 163.

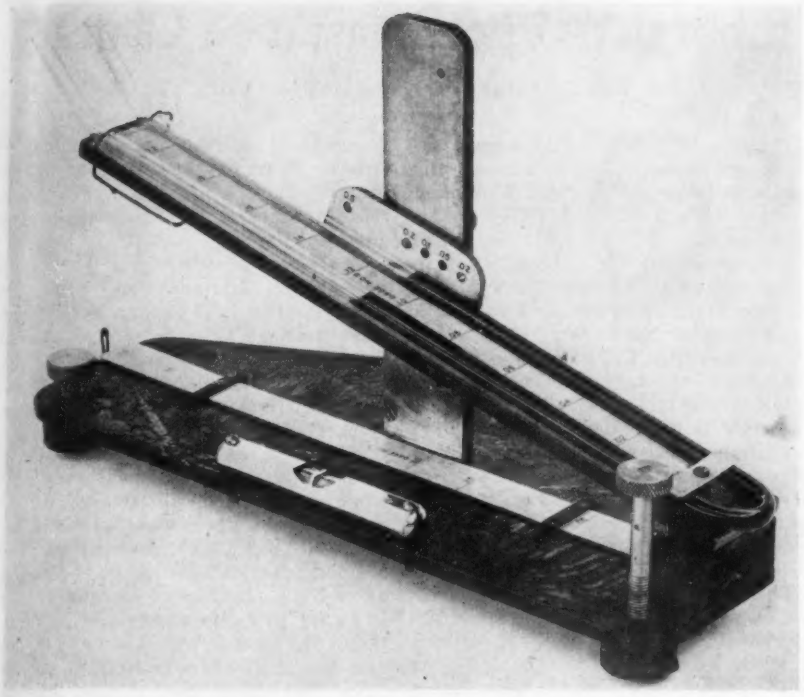


Fig. 2

tained by setting the inclination of the U-tube at an angle which is determined by the range which the instrument is to cover. The instrument is designed for five different ranges of pressure measurement: one-inch displacement of the liquid in the inclined tube is calibrated to represent 0.02″, 0.05″, 0.1″, 0.2″ and 0.5″ of water pressure, respectively. These settings are made positive by means of a tapered pin (A-773-A) which holds the base of the inclined U-tube at the correct angle.

The U-tube is made of 6-mm. Pyrex tubing formed to the shape indicated in the drawing. It is essential that the entire length of the tube lie flat on its base, as any deviations from this flat surface will cause the gage to be inaccurate. The lower end of the glass tube is held down on the tube base by means of a small strip of spring brass (A-984-A) and a screw. The open side of the "U" must be so fastened to the tube base to allow sliding the scales, permitting direct reading of the differential pressure. For this reason, this end of the "U" is held in position by a spring bracket (A-983-A), formed to fit over each leg of the "U" and then fastened to the underside of the tube base.

The scales are made of strip brass and covered with a ruled paper which has twenty divisions to the inch. Only three such scales are necessary, as the readings on the 0.02″ and 0.05″ range scales are duplicated on the 0.2″ and 0.5″ range scales except for the factor 10. Therefore, two strips of the brass suffice to make the scales for all of the five different settings of the instrument, using both sides of one strip and one side of the other. Two small brackets and a spring clip serve to hold the scales to the base of the gage when they are not in use.

The scales are lettered for each of the settings and lacquered to protect them from dirt and handling.*

The fluid used in this gage is xylene. This was chosen because of its low vapor pressure and its rapid response to changes in pressure differential. In order that it might be more easily seen, it is colored with a small amount of Sudan III, an oil-soluble red dye.

*EDITOR'S NOTE — Lacquer probably serves also to minimize the errors due to lengthening and shortening of paper strips with changes in humidity: the length of a strip of uncoated paper may be 2% or even 3% greater in humid summer weather than in "bone-dry" air.

Calibration

The instrument is calibrated by means of a Wahlen Gage,[2] a manometer which is accurate to 0.001″ of water. Each setting is calibrated individually. A small plate, fastened vertically to the inside edge of the inclined base, moves parallel to the vertical support member. The required angle of the tube base is determined and a "C" clamp is tightened over the small plate and the vertical member. This clamp holds the inclined-tube base securely in position while a 1/16″ drill is used to make a guide hole through both. A No. 36 drill is then used to make the guide for the tapered reamers (No. 3/0 and No. 0), which are used in the order named to make the tapered hole which later receives the tapered pin (A-773-A), turned with the same taper as that of the reamers. All this is done with the clamp holding the inclining base securely to the upright. This is the most critical part in the construction of the gage, as the slightest change in position will affect the accuracy of the instrument. This is especially true of the lowest setting, where one inch equals 0.02″ of water pressure. All of the settings are calibrated in the same manner.

Accuracy

When calibrated correctly, the gage has been found to be accurate to plus or minus one division of the scales, which amounts to ±.001″, ±.0025″, ±.005″, ±.01″ and ±.025″ for each of the five scales, respectively. The gage has been found to be reliable, simple in its operation, and rugged.

(2) A. C. Willard, A. P. Kratz and V. S. Day, "Investigation of Warm-Air Furnaces and Heating Systems," University of Illinois, *Engineering Experiment Station Bulletin No. 180*, 1929, chapter IX.

American Association for the Advancement of Science

Gibson Island Research Conferences, 1946

Conference "J"—Instrumentation—Aug. 19-23

R. D. Webb, *Chairman* — C. O. Fairchild, *Vice-chairman*

August 19

A. Keith Brewer. "The Mass Spectrometer; Its Principle of Operation and Its Application to Practical Analytical Problems."

H. L. Andrews. Topic in Spectroscopy to be announced later.

R. C. Machler and A. J. Williams, Jr. "Recording Methods in Spectrochemical Analysis."

August 20

Gordon S. Brown, C. E. Mason, A. C. Hall, A. F. Sperry *et al.* "Theories of Automatic Control."

G. A. Philbrick. "Demonstration of Effects of Various Methods of Control."

August 21

Gordon B. Sayre. "Applications of Modern Plastics in Instruments."

W. F. Swann. "New Photographic Materials and Methods."

V. Lawrence Parsegian. "A New Galvanometer."

J. E. Tweeddale. "New Infrared Receiver With Amplifier."

August 22

Charles F. Kettering. Subject to be announced later.

John J. Grebe. "Application of Control Principles to Human Endeavor."

August 23

R. B. Sosman. "Pyrometric Control of the Open-hearth Furnace."

Gibson Island is about 20 miles from Baltimore, Md. It is owned by a private club. The AAAS owns one building and has arrangements with the club for serving meals and otherwise accommodating Research Conference Participants. Applications for participating in a Conference should be addressed to Dr. Sumner B. Twiss, Chemistry Dep't, Wayne University, Detroit 1, Mich.

Applications of Unbonded-type Resistance Gages*

By RICHARD D. MEYER, Engineer, Statham Laboratories, Los Angeles, Calif.

IN 1857 a submarine cable was laid across the Atlantic ocean. This project was replete with difficulties and it was necessary to evolve many new processes and devices before satisfactory operation was obtained. Sir William Thompson, later Lord Kelvin, was retained to aid in the development of the necessary equipment. Among the devices he invented was an instrument for making rapid measurements of the ocean's depth. It consisted of a piece of resistance wire which changed resistance with the pressure to which it was subjected as it was lowered to the ocean floor. The resistance change was calibrated in terms of depth. Since then, high pressures have been measured frequently by similar devices.

Thus, for many years a force has been caused to produce strain in a wire and the resultant change of resistance measured as a determination of the force. If a wire is subjected to tensile stress, its length will increase and its diameter will decrease. The ratio of its transverse contraction per unit length to its elongation per unit diameter is known as Poisson's Ratio and is one of the characteristics of every metal. The volume of the wire is expressed by the formula $V = \pi r^2 L$. Differentiating this equation, and letting $dV = 0$, so that the volume remains constant, gives Poisson's Ratio $(dr/r)/(dL/L) = -0.5$. Actually, Poisson's Ratio for most metals is between -0.25 and -0.30, indicating that dV is not equal to 0, and that a decrease of density occurs with tensile stress.

The relation between the strain to which a wire is subjected and its change of resistance is known as the gage factor. It is, by definition, $C = (dR/R)/(dL/L)$, where R = resistance in ohms. This gage factor is a characteristic of every metal and alloy and varies widely.

At first thought, it would seem that the material with the highest gage factor would be used most advantageously, but this is not always true. It may be calculated that if the conductivity of the material does not vary with density the gage factor will be 2.0. Since the density is also a function of temperature, it would be expected that a material with a gage factor of 2.0 would have excellent resistance temperature stability, and this is found to be true by experiment. An alloy of 55% copper and 45% nickel, which is widely used in strain gages, has a gage factor of approximately 2.1 and an extremely low thermal coefficient of resistance. Materials with higher or lower gage factors are found to have much higher coefficients.

Several years ago, the phenomenon discussed above was incorporated into an instrument which has found wide application in stress-strain measurements and stress analysis, namely, the resistance wire strain gage. This gage consists of a grid of 0.001"-diameter wire, usually 55% copper and 45% nickel, cemented to a piece of thin paper and covered with a second piece of paper for protection. Connecting leads of copper wire are soldered to the ends of the grid. The gage may then be cemented to the surface of the member in which the strain is to be measured. The wire is thus effectively bonded to the member and will change length in accordance with strains on the surface to which it is applied. It is customarily connected in a bridge circuit with either a d-c. or a-c. power supply, or it may be used in a carrier system.

The gage factor of the complete gage will be somewhat lower than that of the wire, owing to the comparatively unstrained wire in the turns at the ends of the grid. In practice, the gage factor will generally be between 1.75 and 2.05, depending on the dimensions of the gage.

When a resistance wire strain gage is connected as one element of a Wheatstone bridge which is perfectly balanced when the gage is not subjected to strain, the output current of the bridge may be expressed by the formula

$$I_g = \frac{\Delta R}{4R}\left(\frac{E}{R + R_g}\right),$$

where I_g = current through the galvanometer
R = resistance of each bridge element
ΔR = change in resistance of one bridge element only
E = voltage applied to bridge
R_g = galvanometer resistance

To determine the order of magnitude of the output current, a hypothetical case may be computed. Using one active gage, with a resistance of 120 ohms and a gage factor, C, of 2.0, applied to a steel member which is to be stressed to 90,000 lbs./in.^{2}, it is found that

$$\text{Strain} = \frac{\text{stress}}{\text{modulus}} = \frac{90{,}000}{30 \times 10^6}$$
$$= 0.003 \text{ in./in.} = \Delta L/L$$

By definition, $\Delta R/R = C(\Delta L/L) = 0.006$ ohms/ohm

$$\text{Then } I_g = \frac{0.006}{4}\left(\frac{E}{120 + R_g}\right).$$

Assuming that $E = 6$ volts and $R_g = 35$ ohms

$$I_g = \frac{0.006}{4}\left(\frac{6}{120 + 35}\right)$$
$$= 58 \times 10^{-6} \text{ amperes}$$

which is adequate for use with a panel type microammeter, light-beam galvanometer, or recording potentiometer. If two or four of the elements of the bridge consist of active strain gages, the output current will be doubled or quadrupled.

These paper strain gages are quite inexpensive and do not affect the strength or weight of small or delicate structures. When carefully applied, they are remarkably accurate, the precision of measurement obtainable being limited in most cases by the accuracy of the indicating instrument.

Many devices have been made to utilize strain gages for measuring pressure, acceleration, force and weight. Such instruments have been of extreme value, although they have not all given complete satisfaction. A good example of such an adaption of the strain gage is found in an accelerometer, such as might be used for measuring the normal acceleration encountered in an airplane recovering from a dive. Typical, though not necessarily the ultimate of this type of instrument, is the beam accelerometer whose design will be discussed.

If a cantilever beam, clamped at one end, has a weight attached to the other end and strain gages applied to the beam (Fig. 1), the gages will measure

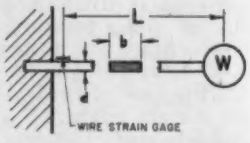


Fig. 1. Typical beam and strain gage accelerometer.

the bending of the beam, which is a function of acceleration.

Suppose the accelerometer is to have a range of ± 12 G and the beam is to be of steel, stressed to a maximum of 90,000 lbs./in.^{2}, resulting in a strain of 0.003 in./in. Let the dimensions of the beam be

$b = 0.5"$ $\quad d = 0.125"$
$c = d/2 = 0.0625"$ $\quad L = 3.0"$
and the modulus of elasticity, $E = 30 \times 10^6$

For a beam of rectangular cross-section, the moment of inertia,

$$I = \frac{bd^3}{12} = \frac{0.5 \times 0.125^3}{12} = 8.14 \times 10^{-5}$$

and the section modulus,

$$S = \frac{I}{c} = \frac{8.14 \times 10^{-5}}{0.0625} = 1.30 \times 10^{-3}.$$

The bending moment, $M = PL = WGL$

where P = Force on end of beam
W = Weight at end of beam
G = Acceleration constant

$$M = W \times 12 \times 3 = 36W$$

*Presented before California Section, I.S.A.

Then the stress, $s = \frac{M}{S} = \frac{36W}{S}$

and $W = \frac{sM}{36} = \frac{90{,}000 \times 1.30 \times 10^{-3}}{36}$

$= 3.25$ lbs.

The deflection of the end of the beam and the weight, W, at *1 G*, is

$$X = \frac{WL^3}{3EI} = \frac{3.25 \times 3^3}{3 \times 30 \times 10^6 \times 8.14 \times 10^{-5}}$$

$= 0.012'' = 0.001$ ft.

The natural frequency of the system is expressed by the formula,

$$f = \left(\frac{A}{4\pi^2 X}\right)^{1/2} = \left(\frac{32.2}{4\pi^2 \times 0.001}\right)^{1/2}$$

$= 28.5$ cps.

This instrument is very good for the measurement of accelerations with no high-frequency components or rapid variations. Its weight will be around five or six pounds.

Another adaptation of the resistance wire strain gage to instrumentation is in the measurement of pressure. The gages may be attached in various configurations to pipes, Bourdon tubes or diaphragms. For reasons of safety, it is not possible to apply large strains to such devices, hence the output of the gages is low. Where low output can be tolerated, either because a highly sensitive indicator is used, or because extreme accuracy is not required, such instruments may be used with good results. Similarly with devices for using strain gages to measure other forces and movements, the results obtainable are generally limited by the requirements of the structure on which the gage is mounted.

Principle of Unbonded-wire Gages

Many of the limitations of the conventional resistance wire strain gage, in which the strain-sensitive wire is bonded to a surface which is to be strained, may be eliminated by the use of unbonded strain sensitive wire. When so used, the wire is wound between two posts which are caused to move slightly with relation to one another. A gage constructed in this manner is shown in Fig. 2. In the center of a stationary frame, an armature is supported by two flexible cantilever plates. These plates support the armature rigidly in the plane perpendicular to the longitudinal axis, but allow free movement along this axis. Wound around rigid pins are four windings of strain-sensitive wire which comprise the four elements of a Wheatstone bridge. As the armature is caused to move longitudinally by an external force, the strain in one pair of windings increases while in the other pair it decreases. Sufficient initial tension is applied to the wires during assembly to keep them under some residual tension when the armature is in either extreme position. Unlike the paper-bonded strain gage which may be wound without particular regard to the initial tension in the wire, the unbonded type must have its tension carefully controlled. This is accomplished by specially designed winding equipment.

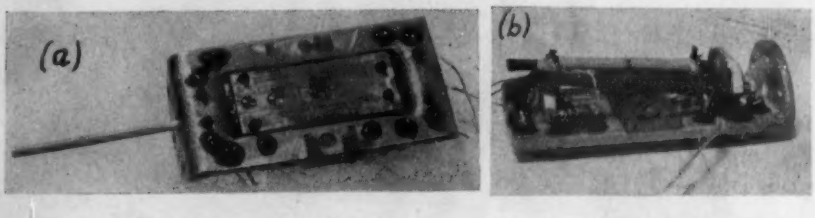


Fig. 2. Statham Gage containing four elements of a balanced Wheatstone bridge (actual size).—(a) Top view, showing strain-sensitive windings; (b) bottom view, showing cantilever, armature, suspension plates, balance resistor and travel limiting stop. (The lead wires are used during balancing.)

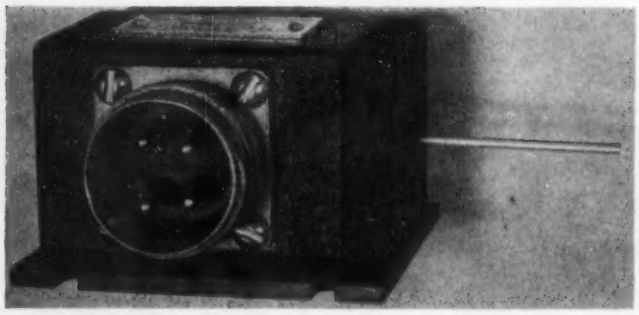


Fig. 3. Statham Gage dynamometer (actual size).

The armature travel is limited by a pin on the armature which fits into a hole on a cross-piece fastened to the frame. The wires are thus protected against overload.

Since the displacements involved are extremely small, it is not possible to construct the instrument so that the resistances of all four windings are exactly equal. A variation of 0.0001″ in the length of a winding, for example, would result in a noticeable unbalance of the bridge circuit. Also, the wire is subject to slight variations in diameter which will cause the windings to have slightly different resistances. In order that the bridge shall be balanced so that there is no output current when no external force is applied to the armature, a small resistor is connected in series with one of the windings as needed. Its value (1% or less of the resistance of each winding) is adjusted during assembly of the instrument to give proper balance.

The unit is symmetrical, both electrically and mechanically, and consequently changes of dimensions due to temperature will balance and will not result in a shift of zero balance or a change in the reading. A slight change in the modulus of elasticity of the strain wire occurs at extremes of temperature, so that the sensitivity increases about 4% as the temperature rises from room temperature to 250°F., and decreases the same amount when the temperature drops to −65°F.

This gage functions either as a dynamometer or as a strain gage, depending on whether it is used to measure a force applied to the armature or to measure displacement. If used as a dynamometer, it will measure forces from ±2 ounces to ±3 pounds full-range, depending on the number of turns and the diameter of the wire in each of the four windings. Lever arrangements may be used when it is desired to measure larger or smaller forces.

As a strain gage, the maximum displacement of the armature is 0.0015″ each side of center. Other displacements may be measured by using suitable connections. The complete instrument is shown in Fig. 3.

Fig. 4 illustrates the manner in which strain amplification may be obtained

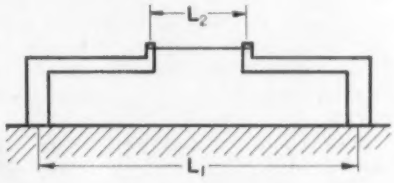


Fig. 4. Method of strain amplification.

when a unit as described above is used.

Strain is by definition $\Delta L/L$

The strain in the structure is $\Delta L_1/L_1 = S_1$.

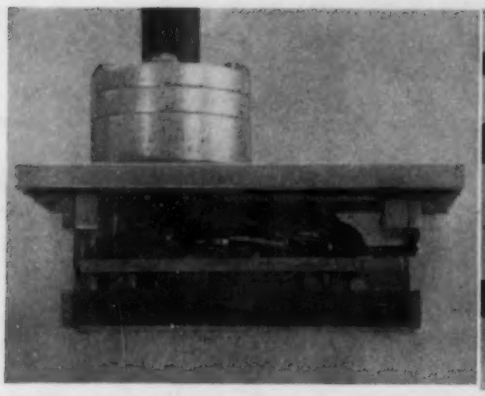
and the strain in the wire is $\Delta L_1/L_2 = S_2$.

The strain in the wire is then greater than the strain in the structure in the ratio

$$\frac{S_2}{S_1} = \frac{\Delta L_1}{L_2} \div \frac{\Delta L_1}{L_1} = \frac{L_1}{L_2}$$

When this gage is used in this manner, the amplification will be equal to the distance in inches between the point of attachment of the gage and the point to which the actuating pin is connected.

The greatest possible output may be had by this means, even though the structure is under very little strain. This gage is thus seen to cover a different field from that of the cemented resistance wire strain gage; and seems better adapted to instrumentation.



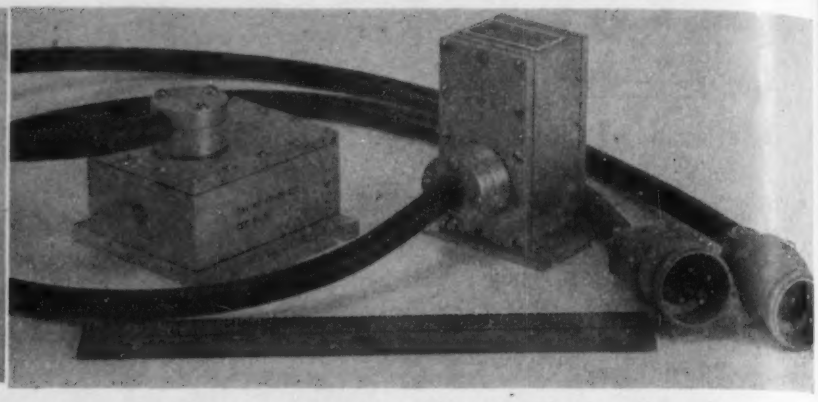


Fig. 5. *(left)* Inside view of Statham Gage accelerometer (actual size). Gage frame is mounted on weight; armature is connected to accelerometer case by a driving pin. Fig. 6. *(right)* Statham Gage accelerometers mounted for response to horizontal (left) and vertical accelerations. (Half actual size.)

Accelerometer

If a weight is fastened to the armature of the strain gage unit, it becomes an accelerometer. Forces resulting from acceleration are applied, not to a comparatively stiff beam, but to the strain-sensitive wires alone. The weight, therefore, may be very light and its total displacement very small. In the Statham Gage, the displacement is 0.0015″ in either direction. This movement is obtained by application to the armature of a force of one ounce per loop of 0.001″ wire, or one-half ounce per loop of 0.0007″ wire. As there are four separate windings, the number of loops will be multiples of four. For example, if an accelerometer is to have a range of ±12 *G*, and each winding is to consist of two loops of 0.001″ wire, a force of eight ounces will be required. Since this force will be exerted when the weight is given an acceleration of 12 *G*, the weight must be 8/12 ounce. The total weight of the complete instrument need be only a few ounces.

Because of the extremely small displacement of the weighted armature, the natural frequency of this type of accelerometer is much higher than that of the weighted beam accelerometer previously described. Using the formula for natural frequency,

let $$f = \left(\frac{A}{4\pi^2 X}\right)^{\frac{1}{2}},$$

$A = \text{G} \times 32.2$ ft./sec.^{2} $= 12 \times 32.2$ ft./sec.^{2}

$X = 0.0015'' = 0.000125$ ft.

$$f = \left(\frac{12 \times 32.2}{4\pi^2 \times 0.000125}\right)^{\frac{1}{2}} = 255 \text{ cps.}$$

This permits measurement, not only of static or near static accelerations, but of vibrations of fairly high frequency. For example, the major components of vibration caused by an aircraft engine running at full speed are well within the frequency range of the instrument.

The instrument just described is illustrated in Figs. 5 and 6. All accelerometers of this type are built around the Statham gage, the range being determined by the attached weight and number of loops and diameter of the strain-sensitive wire. Its characteristics are not necessarily optimum for all applications. As in all design work, compromises are necessary. The use of shorter wires decreases the displacement, thus increasing the natural frequency, but reducing the output power. If a heavier weight and a larger number of wires are used, the output power is increased (as well as the size and weight of the instrument), while the natural frequency is lowered. The dimensions of this type in ranges of ±5 *G* to ±200 *G*, mounted to respond to accelerations normal to the base, are 1⅞″ wide × 1¼″ deep × 2⅜″ high, and the weight is approximately six ounces. The ±2 *G* model, mounted to respond to longitudinal accelerations, is 2⅜″ wide × 1½″ deep × 2⅜″ high, and the weight is approximately eleven ounces.

As the range of the accelerometer depends upon the weight attached to the armature and the number and diameter of the strain-sensitive wires by which it is supported, a wide selection of ranges may be obtained by varying these factors. Accelerometers have been constructed with ranges as low as ±1.2 *G* and as high as ±1,000 *G*. (Fig. 7). It is quite possible to extend these limits almost indefinitely.

It must be noted that the natural frequency is different for different ranges. From the above frequency formula, it is seen that if the total displacement is constant (in this case ±0.0015″) the frequency will vary as the square root of the range. For instance, an accelerometer of this type with a range of ±24 *G* will have a natural frequency $\sqrt{2}$ times that of the ±12 *G* instrument, or 360 cps.

Another type of accelerometer, smaller and lighter, and with a higher natural frequency, is shown in Fig. 8. The strain-sensitive wires in this unit are shorter than those in the instrument previously described, and a somewhat different plan of construction is followed. This type is made in ranges of ±12 *G* to ±200 *G*; and is mounted to respond to accelerations normal to its base. Its dimensions are 1 1/16″ wide × 1⅜″ deep × 1 15/16″ high. The weight of this accelerometer is approximately three ounces, varying slightly with the range. In the ±12 *G* range, the natural frequency of this type accelerometer is approximately 350 cps., making it especially suitable for applications requiring a smaller and lighter instrument capable of operating at higher frequencies.

When a simple spring construction, such as is utilized in these accelerom-

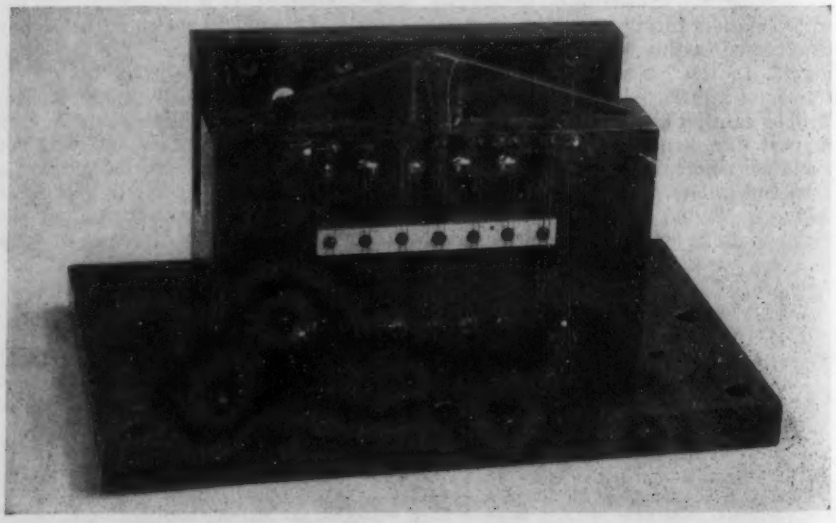


Fig. 7. Special Statham Gage accelerometer for short-duration impact measurements, range ±1,000 *G*. (Actual size.)

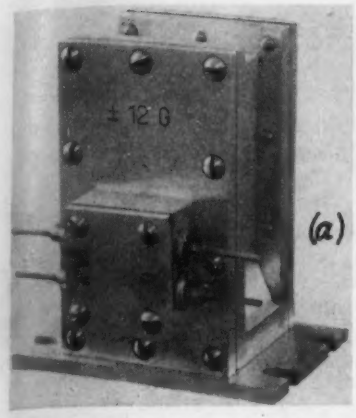


Fig. 8. Statham Gage accelerometer (a) outside; (b) inside. The island in the top of the armature is part of the base. The large head on the screw in the lower cantilever plate clamp assures proper positioning of the unit in the case. (Actual size.)

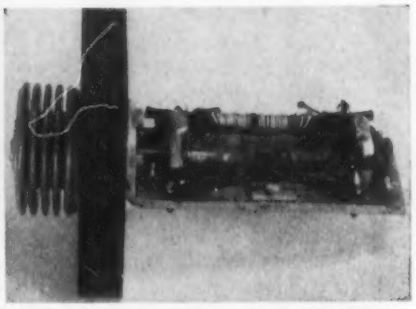


Fig. 10. Bellows type Statham Gage pressure transmitter (actual size). Driving pin is connected to center of bellows at extreme left.

eters, is subjected to vibration, the amplitude of displacement for a given value of acceleration will be practically constant up to a frequency of one-quarter or one-third the natural frequency. At higher frequencies the amplitude will increase. In order to obtain the highest possible useful frequency response, it is necessary to damp the movement of the armature, thus flattening the response curve. This is accomplished by enclosing the unit in a leak-proof case completely filled with damping fluid. The instrument must operate over a wide range of temperature, therefore the fluid used must be one with the smallest possible change of viscosity with temperature, yet it must not affect any of the parts of the instrument and it must be electrically non-conductive. These requirements are satisfactorily filled by the recently-developed organo-silicon fluids. An air-filled expansion chamber, covered by a flexible diaphragm, allows for thermal volume changes of the fluid.

Pressure Transmitters

When its armature is connected to a metallic bellows or diaphragm, the basic gage unit becomes a pressure transmitter. By applying pressure to one side of a bellows and venting the other to the atmosphere, gage pressure may be read. If the bellows is evacuated, absolute pressure is measured. Another modification is to provide two pressure connections, one to each side of the bellows or diaphragm, for the measurement of differential pressure. By connecting such an instrument across an orifice or a Venturi, the flow of liquids or gases may be measured. See Fig. 9.

When a metallic bellows is used, force on the end of the bellows is transmitted by a pin to the armature and the gage unit functions as a dynamometer. If the bellows is limp, so that nearly all of the stiffness of the moving system is due to the strain-sensitive wires, the range of the instrument is a function of the area of the end of the bellows, and the number and diameter of strain-sensitive wires; in other words, the range of the strain gage unit. With this type of construction, gages have been made in ranges of ± 0.5 lbs./in.^{2} to ± 40 lbs./in.^{2}. Fig. 10 is an internal view of this type of pressure gage.

When a diaphragm is used to actuate the armature, the gage measures the displacement of the center of the diaphragm, and the strain-sensitive wire may contribute comparatively little to the stiffness of the moving system. Ranges of ± 100 lbs./in.^{2} and up are possible with this method. Fig. 11 shows a gage with a range of 0-10,000 lbs./in.^{2}.

As with accelerometers, the natural frequency of the pressure transmitter is often of interest. In the instrument using a metallic bellows, this frequency is determined by the weight of the armature, pin and bellows, and by the number and diameter of the strain-sensitive wires. These factors result in a natural frequency of 600 cps. to 1,700 cps., the higher ranges, in general, having the higher natural frequencies, although the two characteristics are not directly correlated.

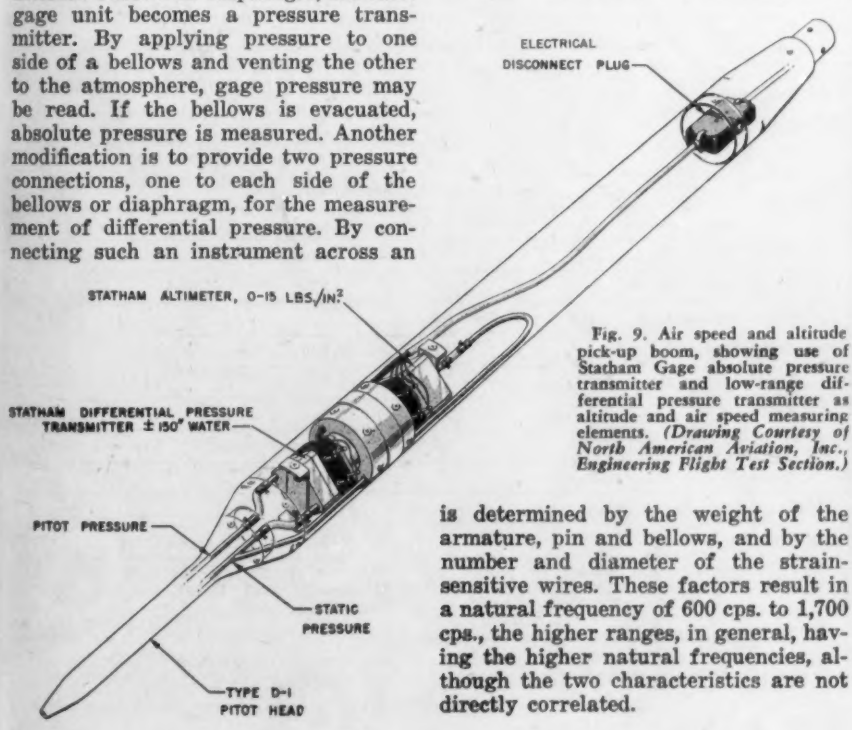


Fig. 9. Air speed and altitude pick-up boom, showing use of Statham Gage absolute pressure transmitter and low-range differential pressure transmitter as altitude and air speed measuring elements. *(Drawing Courtesy of North American Aviation, Inc., Engineering Flight Test Section.)*

Power Supply and Indicating Means

As the electric circuit of Statham Gage instruments is a complete and balanced Wheatstone bridge, the power supply requirement is quite simple. A dry battery is adequate, although alternating current or a carrier system may be used if desired. A wide variety of indicating instruments may be used to measure the output, such as a panel type microammeter, a galvanometer, a standard recording potentiometer, or a recording oscillograph.

These unbonded-wire-type instruments offer a new approach to the measurement of acceleration, pressure, force and movement. Those described herein have been made for applications where extremely rigorous conditions are not encountered. For extreme temperatures or vibrations, corrosive liquids or gases, or other unusual conditions, other types and modifications are possible.

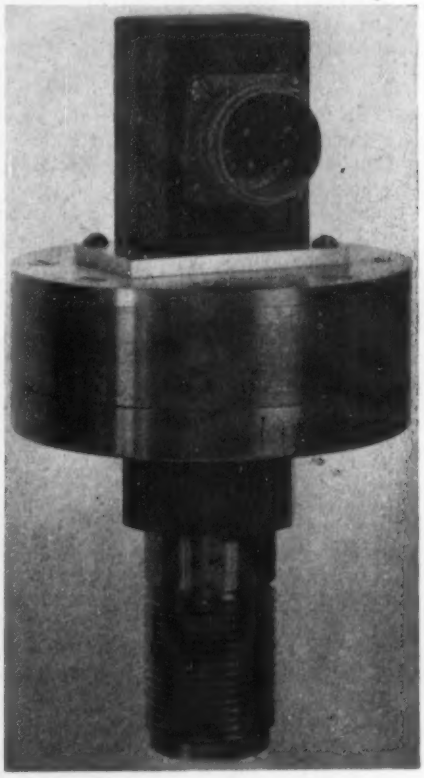


Fig. 11. Statham Gage pressure transmitter (slightly less than actual size). The Statham Gage unit is operated by movement of a steel diaphragm. The range of this transmitter is 0-10,000 lbs./in.^{2}.

Diaphragm-motor Valves and Components*

By LYLE E. EIGE, Fisher Governor Co., Marshalltown, Iowa

I BELIEVE the subject of this lecture needs a bit of preliminary explanation, for my purpose this evening is to discuss those parts of diaphragm-motor valves, such as bodies and plungers, with an eye to their engineering background which quite commonly we accept without too much thought or explanation. The matter of body materials has some interesting side-lights and requires a great deal of technical know-how for its production as a component part of a diaphragm-motor valve.

For instance, the high-tensile iron parts used in diaphragm-motor valves cannot be produced in the same manner as structural shapes, farm implement machinery parts, man-hole covers, etc.

One of the difficulties—now overcome—is pouring from the same cupola irons of different tensile strength for different wall section thickness. In other words, the same iron you would use in an 8" high-tensile iron valve body is not good iron to use on the diaphragm casings.

A common method of doing this is by the Sarbo-Mat process which introduces "dope," as it is called, at the pouring mouth of the cupola, which actually changes the ratio of combined and graphitic carbon. The foundry superintendent, before actually tapping the cupola, surveys the floors and determines, for instance, how many hundreds of pounds of ⅜" section he requires to produce the castings molded that day, and the number of pounds required for thinner sections or for heavy sections. As the cupola is tapped and the iron is poured into the big ladle, commonly termed a bull ladle, the Sarbo-Mat dope is added to the iron as it leaves the cupola at just the right amount to insure proper tensile strength for the various wall thicknesses of the castings being poured. By pouring samples from the bull ladle into iron molds, quickly chilling them, by water quenching, a test can be made before the iron is actually poured in the molds. These molds are prismatic in shape, about 6" long and 1" on each side of the prism. When this is chilled quickly and then broken sharply and cleanly, from the apex, a definite lighter color or grey-colored demarkation is shown. By measuring this with calipers and comparing it to a known chart, we determine the amount of combined carbon or iron carbide which indicates the expectable tensile strength.

For valve bodies in diaphragm-motor valves, which ordinarily have a section at least ½", the tensile strength as cast on this type of iron is 42,500. It has a yield strength as cast of 37,500, a Charpy impact of 2 foot-pounds and a Brinell hardness of 215.

For components such as diaphragm casings, the tensile strength of high-tensile iron normally used when cast is 32,500, and the yield strength as cast of 30,000, Charpy impact of 0.5 foot-pounds with a Brinell hardness of 185.

Tensile strength has long been the yardstick of quality measurement for high-tensile iron. However, tensile strength alone does not satisfy all the requirements of iron for valve bodies, since it is well-known that body castings are subjected to many varieties of stress which are complex and impossible to determine by attention to tensile strength alone. Tensile strength, therefore, in this discussion, embraces tension, compression, transverse breaking loads, shear torsion impact and endurance limits.

In the production of steel castings for diaphragm-motor valve bodies, body bonnets and blind flanges, many problems present themselves long before even the patterns are actually constructed. These problems can best be overcome by close contact with design engineer and foundry source. The foundry source is oftentimes able to point out to the design engineer factors in design that will help in the production of a good quality casting. The steel foundryman can point out changes in design to enable the foundry to pour

SIVYER STEEL CASTING CO.
REPORT ON SPECIFICATION HEATS

Customer, Fisher Governor Co. Date, 10-17-45
Order No. .....
Pattern No. .....
Specification..... Inspected by.....

CHEMICAL ANALYSIS

	Required	*Heat No.*	*Heat No.*	*Heat No.*	*Heat No.*	*Heat No.*
	..	2390	3384	1321-1	3418	3411
Carbon	..	.22	.25	.30	.21	.19
Manganese	..	.73	.74	.95	.69	.74
Silicon	..	.43	.35	1.40	.42	.44
Phosphorus	..	.016	.016	.027	.025	.029
Sulphur	..	.037	.031	.023	.039	.042
Chromium	..	..	..	13.69	..	..
Nickel	..	..	..	.35	..	..
Vanadium	..	..	..	..	..	..
Molybdenum	..	..	..	..	..	..
Serial	..	878	879	880	881	882

PHYSICAL PROPERTIES

Orig. Dia.	..	..	..	..	..	..
Final Dia.	..	..	..	..	..	..
Yield Point Actual.....	..	..	..	..	..	..
Ultimate Load	..	..	..	..	..	..
Yield Point lb./in.².....	..	44,250	50,100	..	40,350	48,800
Tensile Strength lb./in.².	..	75,400	80,650	..	71,150	76,850
Elong. 2".....	..	27.5	28.0	..	28.0	30.5
Red. of Area.....	..	50.6	45.1	..	51.7	51.7
Bend °	..	..	..	..	..	..
Brinell	..	..	..	..	..	..
Charpy Impact	..	..	..	..	..	..

Subscribed and sworn to before me this 17th day of October, 1945.
RUTH L. MUELLER
Notary Public
My Commission Expires Aug. 14, 1949.

These results are as reported by our laboratory and I believe them to be correct.
J. BALFERT, JR.
Metallurgist

Slide 1

*Presented before the Pittsburgh Section, I.S.A., December 17, 1945.

CHEMICAL COMPOSITION AND MARKINGS OF STEEL AND ALLOY STEEL BODIES PER A.S.T.M. SPECIFICATION A216-40T AND A157-40.

GRADE	IDENTIFICATION SYMBOL	PERCENTAGE OF MATERIAL								
		C	MN	P(MAX)	S(MAX)	SI	NI	CR	MO	W
CARBON	WCA *	0.25 MAX.	0.70 MAX.	0.06	0.06	0.50 MAX				
CARBON	WCB *	0.35 MAX.	0.70 MAX.	0.06	0.06	0.50 MAX				
CARBON – MOLYBDENUM	C 1	0.35 MAX.	1.00 MAX.	0.06	0.06	0.20 MIN.			0.40 MIN.	
CHROMIUM – MOLYBDENUM	C3A	0.35 MAX.	1.00 MAX	0.06	0.06	0.80 MAX.		1.50 2.25	0.45 0.65	
CHROMIUM – MOLYBDENUM	C3B	0.35 MAX.	1.00 MAX.	0.05	0.06	0.75- 1.25		1.50- 2.25	0.45- 0.65	
NICKEL CHROMIUM MOLYBDENUM	C 4	0.45 MAX.	1.00 MAX.	0.05	0.06	0.20 MIN.	0.75- 1.50	0.50- 1.00	0.30- 0.50	
4 TO 6% CHROMIUM	C5A	0.15- 0.35	1.00 MAX.	0.05	0.06	0.50 MAX.		4.00- 6.50	0.40-‡ 0.65	0.80-‡ 1.25
4 TO 6% CHROMIUM SILICON MOLYBDENUM	C5B	0.15- 0.35	1.00 MAX.	0.05	0.06	0.75- 1.50		4.00- 6.50	0.40-‡ 0.65	0.80-‡ 1.25
13% CHROMIUM	C6	0.15 MAX.	0.75 MAX.	0.05	0.05	1.00 MAX.	0.80 MAX.	11.5- 13.5	0.50 MAX.	
18% CHROMIUM 8% NICKEL	C9 **	0.15 MAX.	1.00 MAX.	0.05	0.05	2.00 MAX.	8.00 MIN.	18.0 MIN.	AGREEMENT.	
20% NICKEL 8% CHROMIUM	C10	0.35 MAX.	1.50 MAX.	0.05	0.05	2.00 MAX	19.0- 22.0	8.0- 10.0		
NICKEL-CHROMIUM	C11	0.45 MAX.	1.00 MAX.	0.05	0.06	0.20 MIN.	1.0- 2.25	0.50- 1.00	0.20-† 0.40	0.40-† 0.80

‡Either molybdenum or tungsten shall be used.

†Either molybdenum or tungsten may be used if desired.

**For the more severe general corrosive conditions, and when so specified, the carbon content shall not exceed 0.07%.

The addition of such elements as molybdenum, tungsten, titanium, columbium, and vanadium for purposes of stabilization shall be a matter of agreement between the manufacturer and the purchaser.

When the purchaser requires free-machining or better nonseizing, nongalling properties, the composition may contain suitable combinations of selenium and phosphorus, or molybdenum and sulphur:

Selenium and phosphorus:
Selenium 0.20 to 0.35%
Phosphorus max. 0.17%

Molybdenum and sulphur:
Molybdenum 0.40 to 0.80%
Sulphur 0.20 to 0.40%

*For each reduction of 0.01% below the specified maximum carbon content, an increase of .04% manganese above the specified maximum will be permitted up to a maximum of 1.10%.

Slide 3

the parts and properly feed them with the molten metal as they are being poured in the mold.

Even after the patterns have been constructed it is wise that the foundry source study these carefully and it is usual practice for all foremen at the foundry, from Superintendent down, to study these patterns; and the standard of manufacture is then established. The heading and gating are laid out on the pattern equipment and permanent heads and gates are made for the job by the foundry. These heads and gates become then a part of the equipment and are never changed unless some difficulty necessitating a change is reported later. Type and hardness of sand for cores and molds, as well as pouring temperature, are also established before making the first casting. After all this preliminary work has been completed, a sample mold is made under actual production methods and no precautions are taken that are not standard practice. After this sample or tryout has been poured, the casting is subjected to a thorough investigation to determine if all methods set up at the first meeting of minds worked out in practice as they hoped. If satisfactory, the casting is then completely cleaned and annealed and turned over to what is termed the non-destructive test expert who both radiographs and Magnafluxes the casting to see if any defects are present that are not visible to the naked eye.

A bit now as to the composition of steel used in steel castings, commonly called carbon steel castings. The elements always contained in this type of steel and, of course, which can be determined by analysis, are carbon, manganese, silicon, phosphorus and sulphur.

Carbon. In general the tensile strength and yield point increase and ductility decreases with increasing carbon content.

Manganese acts as a deoxidizer on the liquid steel. It also combines with sulphur to form manganese sulphide and prevent "red shortness." Beside increasing soundness, it increases toughness, tensile strength and yield point. The normal manganese content of carbon steel castings is 0.50% to 1%. If cast steel contains over 1% manganese it usually is considered to be an alloy cast steel.

Silicon acts as a deoxidizer and promotes soundness of steel. In normal amounts 0.20% to 0.75%, it has little apparent effect on the tensile properties of steel at room temperature. In some grades of steel silicon is added in larger than normal amounts as an alloy element, particularly in combination with other elements.

Phosphorus. In amounts up to a maximum of 0.05% phosphorus has no practical effect on the structure or properties of steel.

Sulphur content should be kept as low as possible. When steel is deoxidized with critical amounts of aluminum the sulphide inclusions are responsible for falling off of the ductility.

Slide No. 1 is a random affidavit of the chemical and physical properties for each of four heats and shows the contents of the elements above discussed in the four heats. Note that heat number 1321-1 is a high chrome steel and note also that here the silicon reaches the percentage figure of 1.40%, illustrating the fact that when the alloys were used silicon is increased for alloying purposes. Note also heat number 1321-1: it is actually of 410 stainless steel.

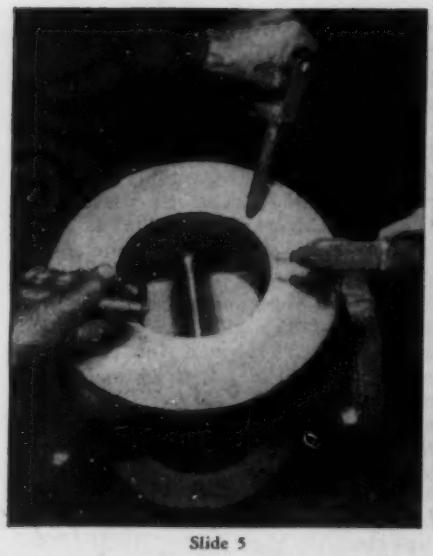
In the process of molding and pouring these diaphragm-motor valve components, attention must be paid to all phases of molding to insure a high and continued quality that these pressure castings require.

The matter of the sand used in the molds and cores presents a science or art by itself. To insure satisfactory results the sand used must be of a consistent grain size; it must retain a certain percentage of moisture and a set standard of permeability. If the grain size is too small, the sand will mold into too compact a mass and make it impossible for the gases from the steel to pass off and thus cause a serious porous condition extremely detrimental to pressure castings. On the other hand, if the grain size is too large it will spoil the appearance of the surface and may also cause the washing away of the sand; and the flowing operation will result in sand inclusions in the casting itself.

If the moisture content is too low the sand will not bind properly, causing a dirty mold condition and sand inclusions in the casting. If the moisture content is too high, steel being extremely allergic to water, this will cause a "blow condition" and results in unsatisfactory castings.

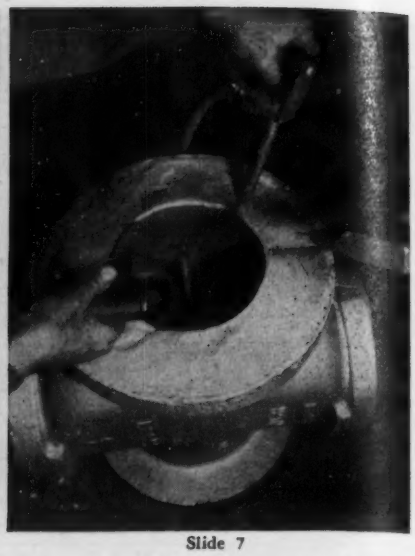
Another factor is that of collapsibility: the physical make-up of the sand to retain its original shape under extreme heat and stress condition. In cooling from the fluid to the solid, steel shrinks roughly ¼" to the foot; if the sand has too high a collapsibility rating and does not collapse at the proper time, the casting will become badly cracked—the only other alternative it has to compensate for the shrinking action. On the other hand, if the sand has too low a collapsibility it will collapse before the steel has become set to the lines of the mold and cause badly distorted and even dirty castings.

To insure against these factors it would be necessary that the foundry source have a complete sand-testing laboratory and run tests on every batch of sand before molding and core-mak-



Slide 5

Slide 6



Slide 7

ing are started, thus insuring uniform results. Surprising as it may sound, even the weather has an important effect on foundry sand and must be taken into consideration when mixtures are made. During rainy weather less moisture is added; during dry days, more.

Another practice which insures good pressure castings for diaphragm-motor valves is the use of new sand on all casting surfaces of the mold, the burnt sand being used only as a mold and backing fill. This method of molding results in cleaner surfaces void of any inclusions.

Thought must be given to the matter of handling the steel itself used in the pouring of these pressure castings. Let's take the factor of pouring temperature which, to the foundry making pressure castings, becomes a very important operation. Untold differences would result in the net result of the casting if some were poured at 3200°F. and others at, say, 2900°F. Each casting has its ideal pouring temperature determined long before molding has started. Pyrometric control of the metal is used to insure that the temperature is correct. This becomes doubly important in pressure castings where grain structure is of vital importance to the performance of the unit. Under no circumstances would a large crystalline structure be satisfactory for pressure castings, whereas a fine uniform structure would give highly satisfactory results. Controlled pouring temperature is the answer.

To the average user of diaphragm-motor valves, a steel body casting is just that and nothing more. However, it is necessary that facilities be established for both the chemical and physical inspection of every heat of metal poured into pressure castings to be used as diaphragm-motor valve components. At the foundry laboratory the means should be available to find out if the carbon and other elements are within the ranges of specification to which they are made. If many of the elements present are out of the specified range, all castings should be scrapped and new ones poured to replace them. Castings of each individual diaphragm-motor valve body, blind flanges, and bonnet castings, should be readily identified by the heat number tagged on the casting, and this should become a permanent record so that it could be referred to at any time to determine the exact analysis used on that individual casting.

Also, test bars should be made to insure that the parts have been thoroughly processed and will give performance up to and over the required standard. Facilities should be available for chemical and physical testing and such an installation should include equipment for processing and photographing micro-structures of specimens of steel as well as fatigue machines, Charpy impact equipment and others.

To illustrate how this information is assimilated and made available, slide No. 2* shows cast steel body markings. The identification symbol (which in this case is C3A) the manufacturer's trade mark and the heat number are to be stamped on the raised tab, but all other markings are to be cast on the body, as well as the pattern number.

In this case the foundry's trade mark is cast on the opposite side of the body. Slide No. 3 shows chemical composition and markings of steel and alloy steel bodies, per ASTM specification A216-40T and A157-40. These are the most commonly used grades of steel and alloy steels used for diaphragm motor valve bodies, blind flanges and bonnets.

In creating proper cast steel and alloy steel castings it is common practice to Magnaflux these castings from time to time, to check quality of the casting, and to aid in determining difficulties which occasionally crop up in the production of steel castings. In Slide No. 4 [Front Cover] we show the elements necessary for Magnafluxing. This shows the cabinet providing the electric current between the two electrodes and also a means of spraying on, by means of a pressure gun, magnetic iron particles between the two electrodes. Not only surface defects but those defects which are not apparent by surface inspection, but are relatively close to the surface, can be revealed by the Magnaflux, and the magnitude of cracks and other faults also determined. In the next Slide (No. 5) we see a valve body about to be tested with Magnaflux. Note the two electrodes held in position so that the wall of the outlet passage can be covered with iron particles from the gun. Slide No. 6 shows where Magnaflux has revealed a defect in the outlet passage. This is shown by the dark line plainly apparent in the slide. In Slide No. 7 we see a casting which reveals no defects when subjected to magnaflux operation.

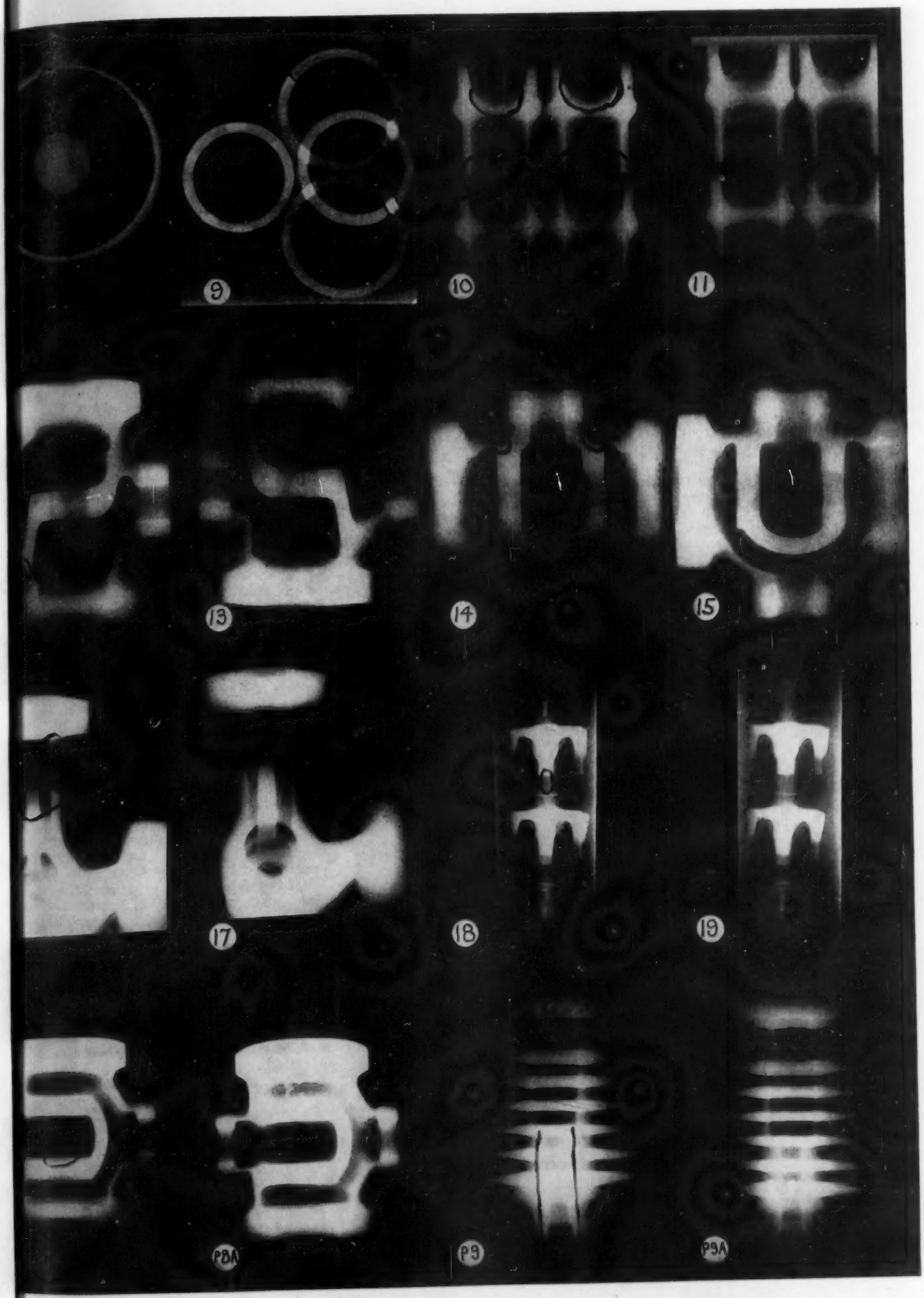
Another method of checking steel castings is the use of gamma rays or x-rays to determine hidden defects such as shrink holes, dirt, porosity and cracks, which are not surface cracks. This is done by surrounding a radium capsule with the steel castings in a properly lead-guarded room, with film properly positioned. There are some definite rules or procedure as to wall thickness of castings compared to distance away from the radium capsule in the center as well as the length of exposure.

Here are some slides giving both good castings and bad castings when gamma or x-rayed:

Slide No.	*Identif'n*	*Remarks*
8	Patt. 2782	Excessive dirt
9	A1996	Porosity
10	Patt. J3183	Porosity
11	Patt. J3183	Good castings
12	Patt. A457 (single seat)	Shrinkage cavity
13	Patt. A457 (single seat)	Good casting
14	Patt. A457 (double seat)	Shrinkage cavity
15	Patt. A457 (double seat)	Good casting
16	Patt. J3181	Serious shrinkage
17	Patt. J3181	Good casting
18	Patt. H639	Shrink in stem
19	Patt. H639	Good casting
P8	Patt. A458 (double seat)	Crack on body
P8A	Patt. A458 (double seat)	Good casting
P9	Patt. H523	Core off-center
P9A	Patt. H523	Good casting

[EDITOR'S NOTE—These sixteen slides have been made up as a full-page illustration.]

*Not suitable for reproduction.


9
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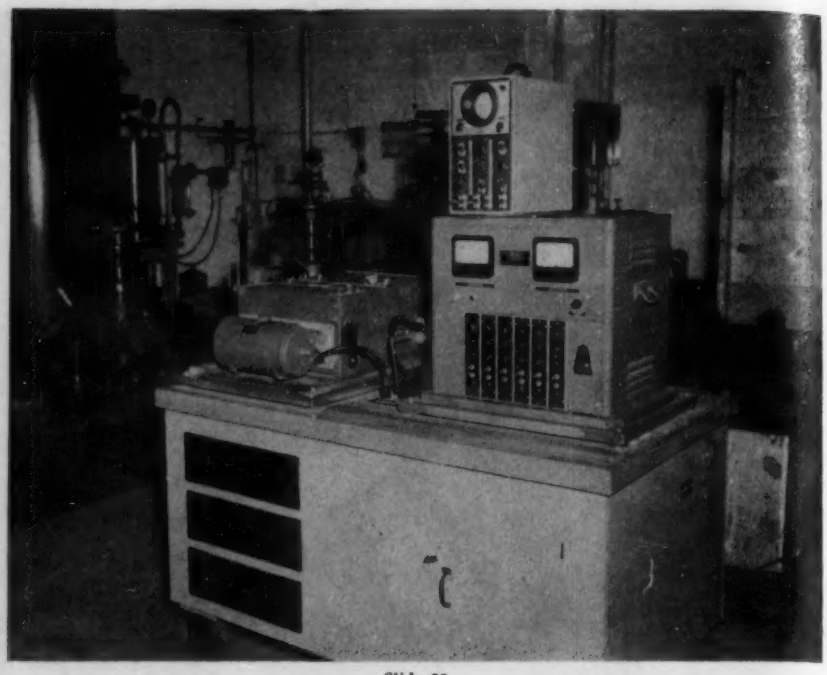
P8A
P9
P9A

Valve bodies should also be tested at the time of assembly as a part of a diaphragm motor valve structure, for leakage of bolting as well as porosity leakage. This can readily be done by means of a hydrostatic test, and a typical manner of hydrostatic testing is shown in Slide No. 20.

The next portion of my discussion will concern itself with some strain gage work on complete diaphragm-motor valve assemblies. We have available in our laboratory equipment which will, by utilizing strain gages, result in an oscillographic record which gives us an instantaneous recording of what goes on in a diaphragm-motor valve under various conditions of pressure, flow, valve travel, etc.

Slide No. 22 illustrates, on the right-hand side, the amplifying unit with the oscilloscope sitting on top of it, which in this instance is used as a balancing element. It can be used for visual indications. The equipment on the left-hand side shows the recording portion of the equipment. Slide No. 23 shows a section of the laboratory and flowmeter run in which the diaphragm-motor valve is installed. We are looking from the downstream side towards the hydropneumatic tanks which provide the inlet capacity when used with a centrifugal pump not shown in this slide. This view also shows the electrical connections to the various strain gages, but we will show each of these in subsequent slides.



Slide 22

Slide No. 24 shows about the same thing, only looking from the upstream side to the downstream side in the meter run and shows the V-notch weir box for measuring flows if such is desired.

Slide No. 25 shows a strain gage set-up to indicate valve travel.

Slide No. 26 shows the channel set-up to record stem force.

Slide No. 27 shows first the usual orifice and orifice flange fittings in the meter run, and then shows the manner in which we utilize the differential across the orifice to actuate a strain gage. In the smaller orifice fitting we actually have between them a diaphragm with a stem member on it to which is attached the strain gages. It is difficult to record flow, in this manner, over a complete range of a diaphragm valve's rangeability because an orifice to indicate both low flow and high flow is rather hard to provide.

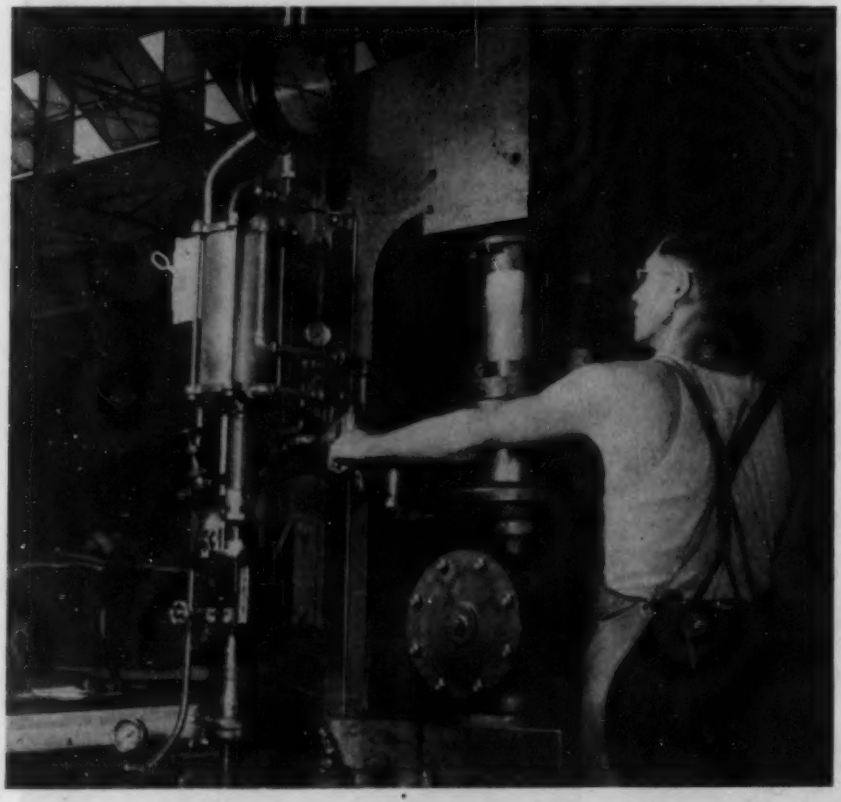
Slide No. 28 shows the channel which records pressure on the diaphragm, and here note that we use pressure head of our own design.

Slide No. 29 shows the same type of strain gage indicating both inlet and outlet pressures.

With these six channels, then, available to record the points that have been described, we used the same diaphragm-motor valve, namely 2" size, and installed in it a characterized V-port inner valve, throttle plug inner valve, which is a formed plunger type with throttling characteristic and the ratio plug type of inner valve which is a formed plunger type of inner valve with equal percentage characteristics.

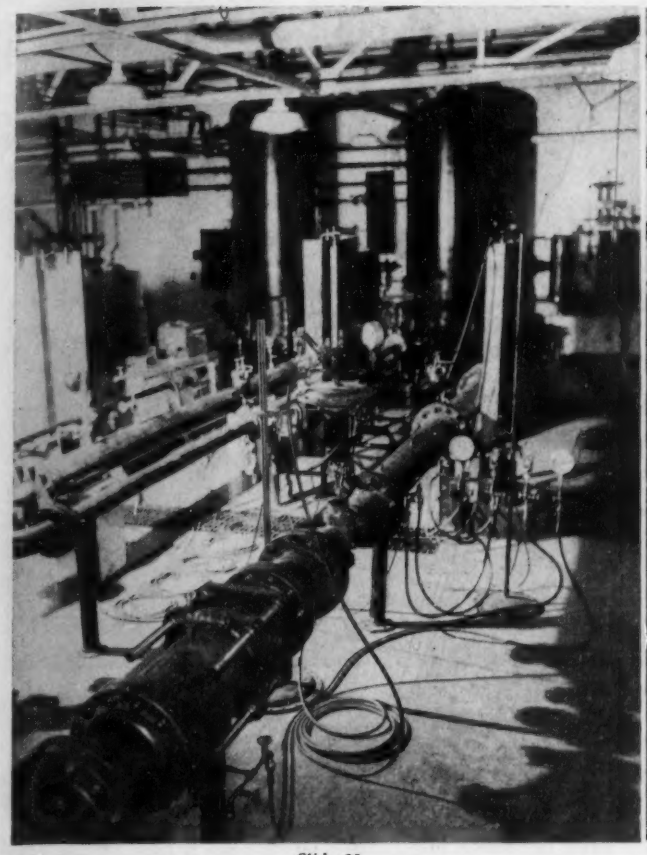
First we applied 50 lbs./in.^{2} pressure drop across the valve body by applying inlet pressure, zero outlet pressure to the body. The next slide* shows actually three different valves with 50-lb. pressure drop. The maximum valve travel of the characterized V-port inner valve, and in the case of the two others, it is 1⅛". We started with 20-lb. pressure available to apply to the diaphragm and then by releasing this pressure from the diaphragm we dropped it down until zero pressure was on the diaphragm, and because these in all cases are direct-acting valves or "push-down-to-close" valves, with zero pressure on the diaphragm, the inner valve was wide open.

Outlet pressure, in any case, failed to read much over 1-lb. value. This value of the outlet pressure under dif-

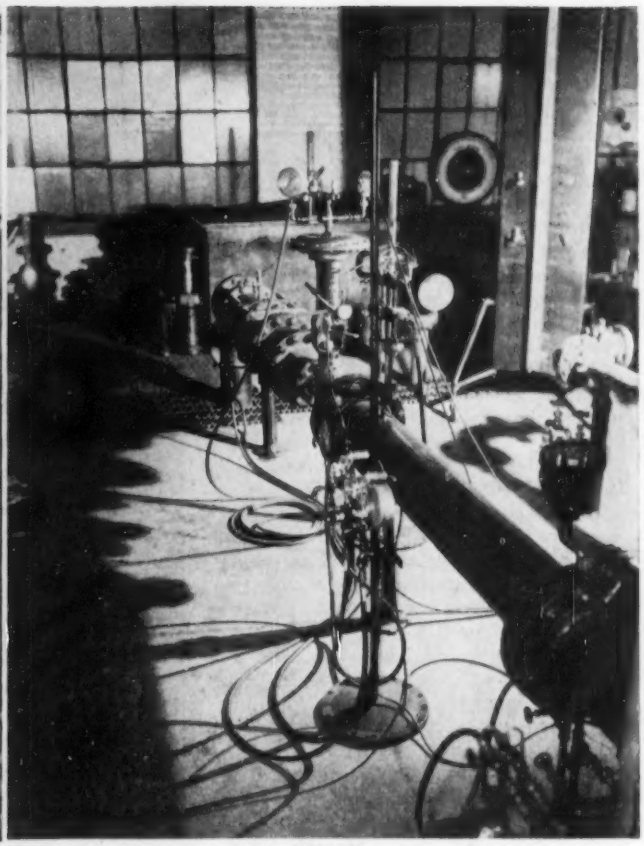


Slide 20

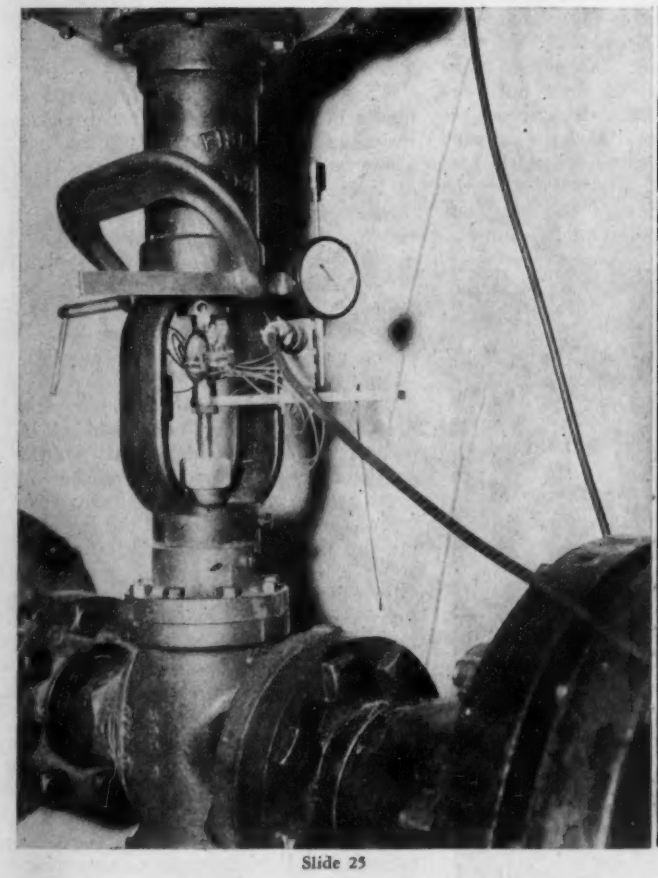
*Slides 30 to 33 incl. were not suitable for reproduction but the text of Mr. Elge's lecture as printed here reports all relevant findings.—EDITOR.



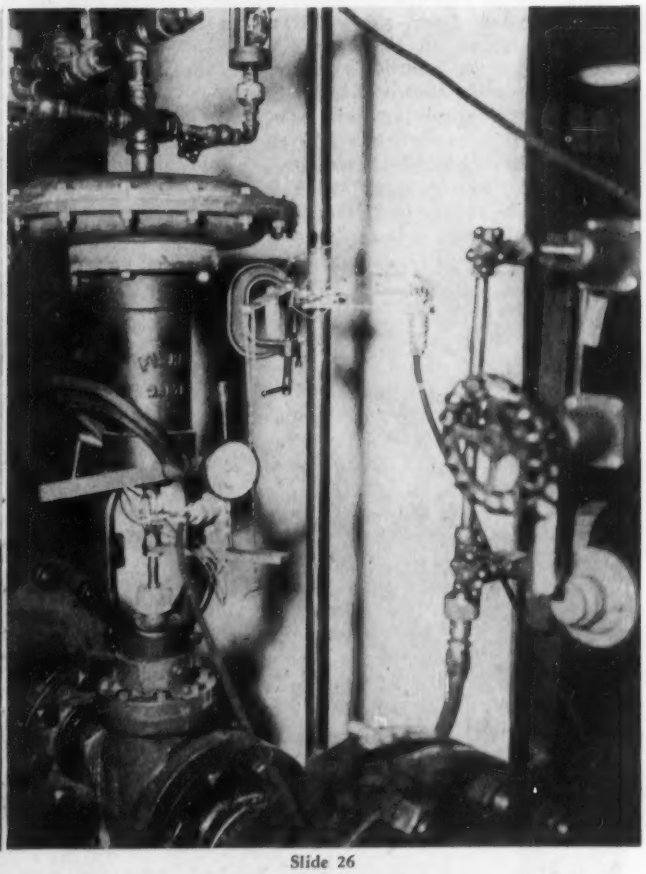
Slide 23



Slide 24



Slide 25



Slide 26

ferent flow and pressure conditions was spilled to a weir tank and, for any practical purposes, the variation of the outlet pressure did not necessarily have to be recorded.

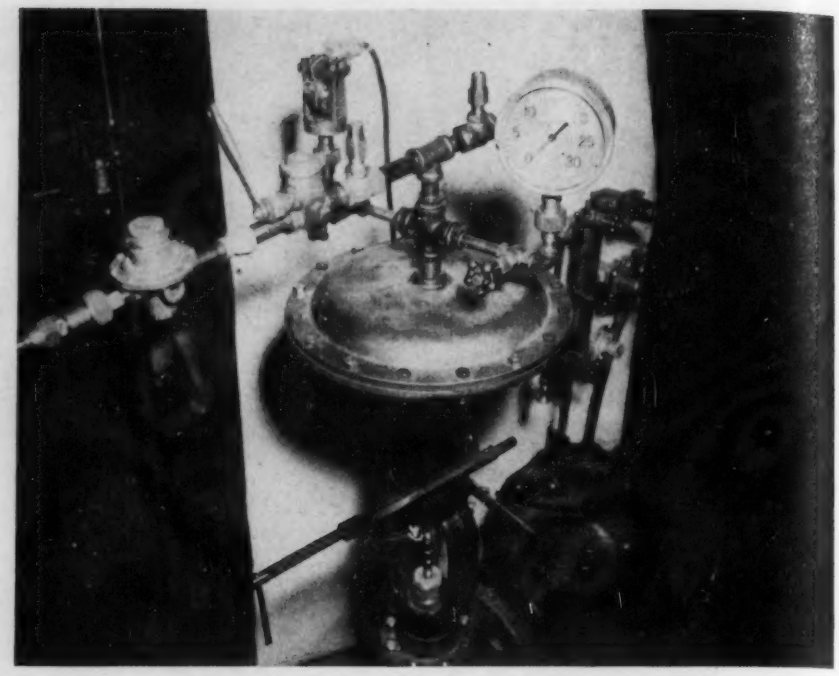
The next channel shows the stem force in pounds. The difference in area in all cases with the 2" valve body on which these tests have been run, amounts

to 0.380 square inches. I believe it is a rather common conception of stem force that it is always in one direction, and in the case of the direct-acting valve in all cases upward or towards the diaphragm with the diaphragm installed above the pipe line. It is found, however, that as the valve opens, flow reaction takes place and that this force diminishes in value in an upward direction and *actually changes direction* and is exerted downward or away from the diaphragm, or, in other words, the force changes and starts downward towards the seat. This upward thrust of the stem we have called the valve stem in compression. The downward pull we have called valve stem in tension.

The inlet proportion is recorded, and in this slide it is shown as 50 lbs.

One thing I want to point out is that the flow in these tests is too small on low values of inner valve lift to create enough differential to show on the graphs. In other words, in the case of the characterized V-port inner valve, as the inner valve leaves its seat we see little or no change in flow. In fact, the valve is surely at least ⅜" opening before we notice the flow leaving the base line as shown. Actually, of course, changing flow is present while the valve is leaving its seat, but owing to the fact that our orifice arrangement was such that it would not create enough differential at low flows, we could not properly record it. If we were interested in recording flow alone we would use a different orifice. In the height above the base line to record maximum flow could be readily shown the full height of the oscillogram. In this case, we didn't do it because we would clutter up our other channel recordings.

Note that as the inner valve leaves its seat, the valve stem is compressed or, in other words, it is pushed up with a force of 24 lbs. As the pressure on the diaphragm is decreased and the valve travel in turn increases, this force tends to diminish and, in turn, reverses itself so that at maximum valve position we actually have the valve in tension or a negative force of 18 lbs. Leaving that for a moment, let us compare now the throttle plug under the same conditions. Note that the flow values are relatively the same. However, the throttle plug does not pass as much under the same drop across the valve body, because its shape is such that it does not expose as much port area. Here we find that owing to the change in the shape of the plug our upward force or the stem in compression now only has a value of 18 lbs. and when the valve approaches the wide-open position we get a negative force or the valve stem intention in the amount of 47 lbs.



Slide 28

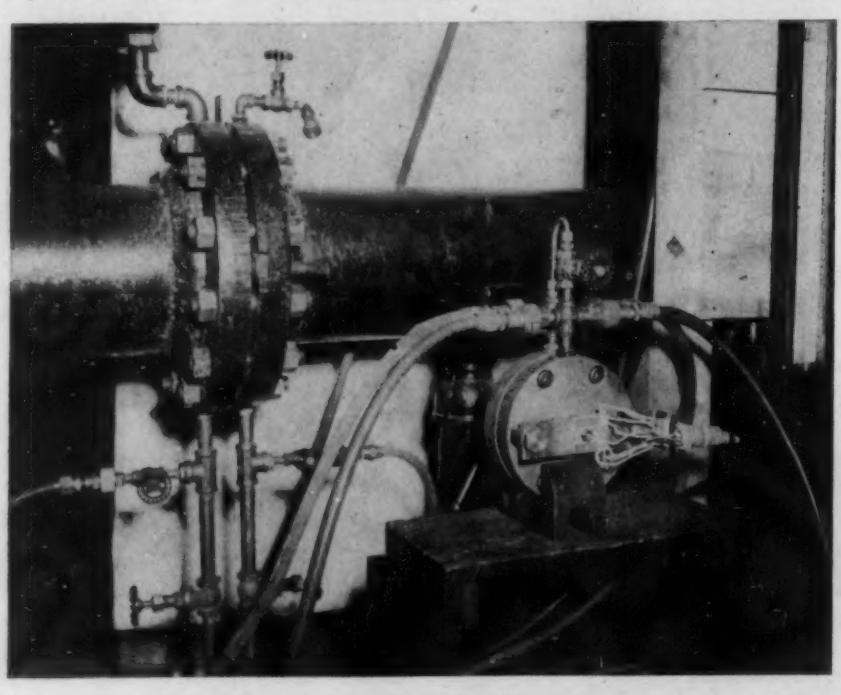
Then let us take a look at the ratio plug, which is an equal-percentage characteristic with a formed plunger, and here we note that the value in pounds with the valve stem in compression amounts to 44.

Slide No. 31* shows the same arrangements of valves but here the pressure drop has been increased to 100 lbs./in.^{2}. Here we find, of course, that the valve stem in all three cases has a greater upward force and we find, again, that this reverse action of the inner valve, or this downward force of the stem, is increasing as the pressure drop increases. Also, we find that we are getting some rapid force changes but not of such a magnitude that we move the stem.

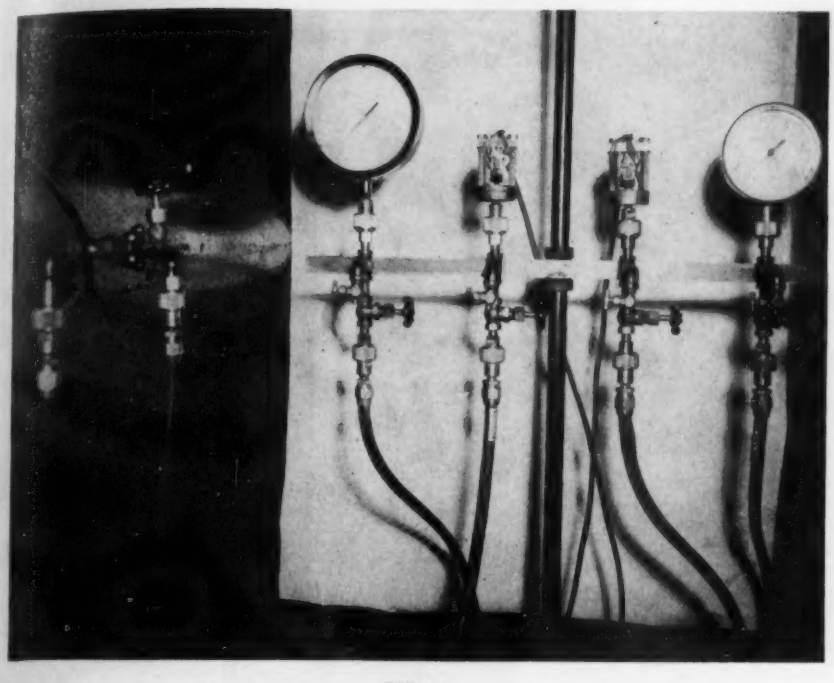
The next slide* shows 200-lb. drop and we are getting some decided increased values in this negative force on the valve stem, and we are showing even greater forces on the stem. Even under these circumstances the pressure on the diaphragm is remaining relatively constant. The diaphragm-motor valve definitely is not in a condition known as cycling or hunting but we can tell what increased drop is doing.

The next slide* shows the action with six valve positions and with inlet pressure being changed zero to 200 lbs./in.^{2} and drop back to zero. The same action with the same lift values taken place on the three types of inner valves, but again in the 2" or same valve body.

Here note that we change the pressure to the diaphragm to a value which gave us exactly ¼" valve travel or lift. In this case, this turned out to be a diaphragm pressure of 12.4 lbs. with zero inlet pressure. Then inlet pressure



Slide 27



Slide 29

was increased gradually to a value of 200 lbs. and we find that owing to the 200-lb. drop we have changed valve travel. We have not changed it much, it is true, but we have changed it from 0.25″ or ¼″ travel to 0.27″. In fact, we have a 200-lb. drop across the valve body, plus the inner valve and stem up to the extent of 0.02″. The pressure on the diaphragm was held constant, but at the time the inner valve was subjected to 200-lb. drop, we find that we move the stem upward; hence, we compress the air on the diaphragm and raise its value to 12.75, or an increase of 0.35 lb.

We next changed pressure on the diaphragm so that we had exactly ½″ valve travel, and this diaphragm air pressure value was 9½ lbs. By doing the same thing with the inlet pressure, we find that again we change valve travel and pressure on the diaphragm.

By changing diaphragm air pressure again to get exactly 1″ valve travel, subjecting it to a 0 to 200-lb. change of inlet pressure, we find about the same results.

The other chart* indicates very similar values for the throttle plug and ratio plug.

Primarily, I believe, we have recorded here the effect of pressure drops of relatively high value, on the diaphragm motor valve, and we have also graphically represented *the amount of pressure a valve positioner would have to apply to the diaphragm* when pressure drop changes on a 2″ valve body size from 0 to 2″, 0 to 200 lbs./in², to position the inner valve correctly and to offset any positioning of the inner valve due to increased pressure drop, or also flow reaction at changing values of flow through the valve body.

Previous to this test work, we had never endeavored to record the reaction of any diaphragm-motor valve in the manner I have discussed in this lecture. Furthermore, we did not have any preconceived idea of what the results were going to be. In fact, we did not even know what we were looking for. It was our belief that an instantaneous recording of a diaphragm-motor valve subjected to these changes as I have discussed would be of interest. I have merely reported to you this evening that which we found.

Acknowledgment.—The author gratefully acknowledges the valuable assistance of Roy Joens, in Charge of Research, and Charles King, Project Engineer, Fisher Governor Company, in the preparation of this lecture.

INSTRUMENTS ON THE MARCH

Flying Laboratory to Expedite Gas Turbine Progress

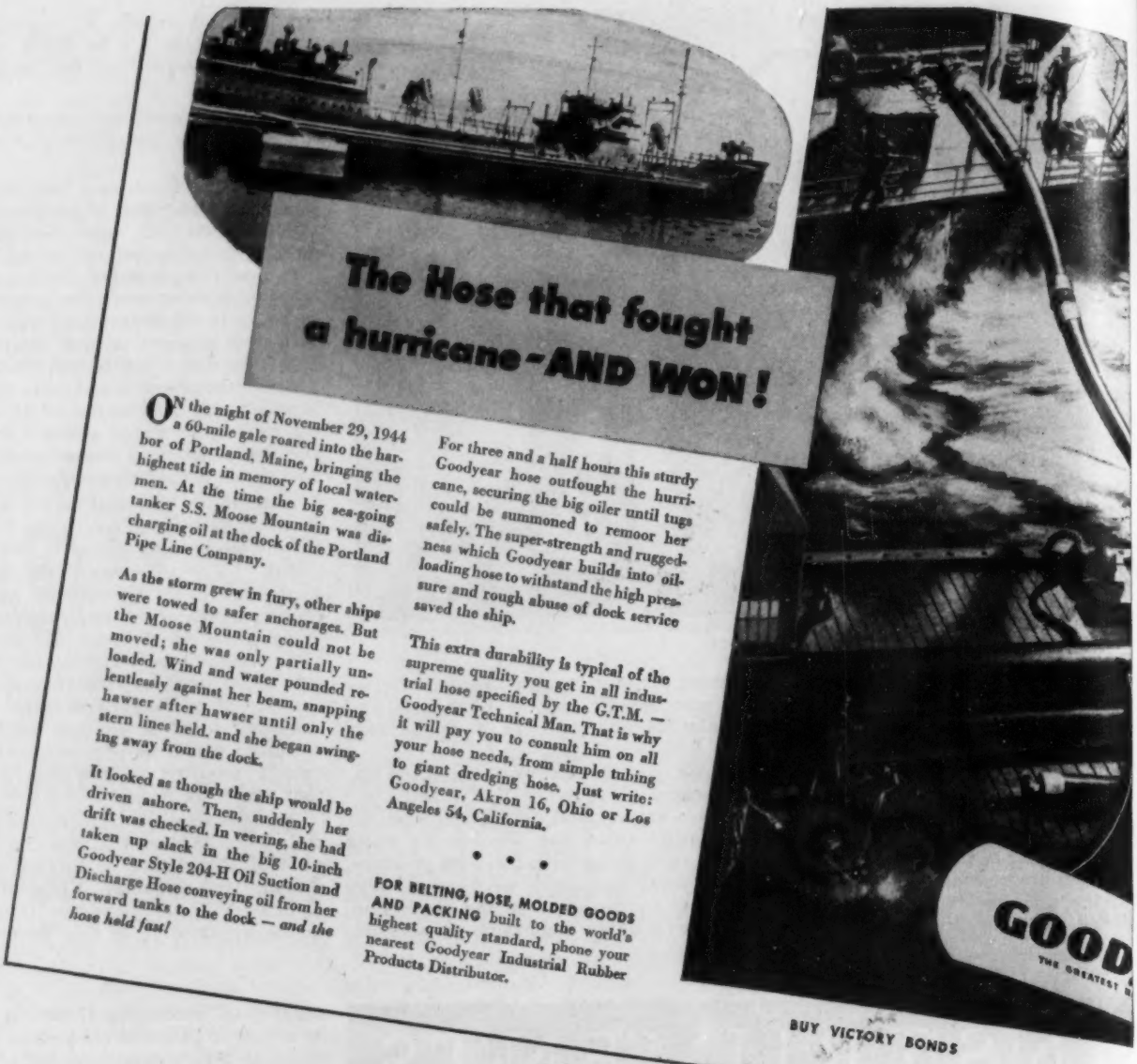
NEW YORK CITY.—A flying laboratory to test aviation accessories and engine parts and especially aircraft gas turbines was described at the annual meeting of The American Society of Mechanical Engineers by N. F. Frischhertz, W. R. Orme and W. O. Meckley, of the General Electric Co. They said that in order to provide flight test facilities to supplement existing ground test apparatus, and to provide greater latitude in developmental testing of aircraft gas turbines, General Electric has modified a B-24 Liberator bomber to carry a jet engine and a large amount of instrumentation to high altitude. Testing of the G. E. Super-Jet engine (used in Lockheed P-80 "Shooting Star") on this aircraft has been in progress for the past four months in coöperation with Pan American World Airways at Brownsville, Texas.

A complete jet engine system is installed in the airplane simulating installation in current production and experimental aircraft. Air is rammed into the machine through a large air-scoop (4.2 ft.²) located on top of the fuselage, over the wing, and the jet is directed rearward through a long tailpipe protruding through the tail of the ship. The engine is installed in the fuselage at the rear of the aft bomb bay. Large cargo doors are installed in the side of the fuselage for loading the test engine. Kerosene is carried in bomb bay fuel cells.

The engine is mounted in a cradle capable of measuring thrust in flight by means of balanced air pistons. In addition to this, a large number of pressures, temperatures, and miscellaneous data can be recorded by means of a self-balancing potentiometer and two large instrument panels, photographed simultaneously by dual mechanically-synchronized cameras. A great number of measuring elements may be rapidly connected to the recording devices.

In testing, the jet engine may be operated at any power, while the four conventional engines maintain constant altitude and airspeed.

"This provides," it was stated, "for safe testing of almost any type accessory or engine part, which during normal course of development may cause engine power failure and inability to make a re-start. In addition, design engineers may go aloft to observe operation of the engine in flight. The installation has been designed to test either of two jet engines of similar size with a minimum of modification. All possible provisions have been made to facilitate rapid engine changes in order that engines with different configurations may be quickly installed and tested, thus speeding development of the gas turbine."


The Hose that fought
a hurricane-AND WON!
ON the night of November 29, 1944 a 60-mile gale roared into the harbor of Portland, Maine, bringing the highest tide in memory of local watermen. At the time the big sea-going tanker S.S. Moose Mountain was discharging oil at the dock of the Portland Pipe Line Company.
As the storm grew in fury, other ships were towed to safer anchorages. But the Moose Mountain could not be moved; she was only partially unloaded. Wind and water pounded relentlessly against her beam, snapping hawser after hawser until only the stern lines held, and she began swinging away from the dock.
It looked as though the ship would be driven ashore. Then, suddenly her drift was checked. In veering, she had taken up slack in the big 10-inch Goodyear Style 204-H Oil Suction and Discharge Hose conveying oil from her forward tanks to the dock — and the hose held fast!
For three and a half hours this sturdy Goodyear hose outfought the hurricane, securing the big oiler until tugs could be summoned to remoor her safely. The super-strength and ruggedness which Goodyear builds into oil-loading hose to withstand the high pressure and rough abuse of dock service saved the ship.
This extra durability is typical of the supreme quality you get in all industrial hose specified by the G.T.M. — Goodyear Technical Man. That is why it will pay you to consult him on all your hose needs, from simple tubing to giant dredging hose. Just write: Goodyear, Akron 16, Ohio or Los Angeles 54, California.
• • •
FOR BELTING, HOSE, MOLDED GOODS AND PACKING built to the world's highest quality standard, phone your nearest Goodyear Industrial Rubber Products Distributor.
GOOD
BUY VICTORY BONDS

TAYLOR ACCURACY

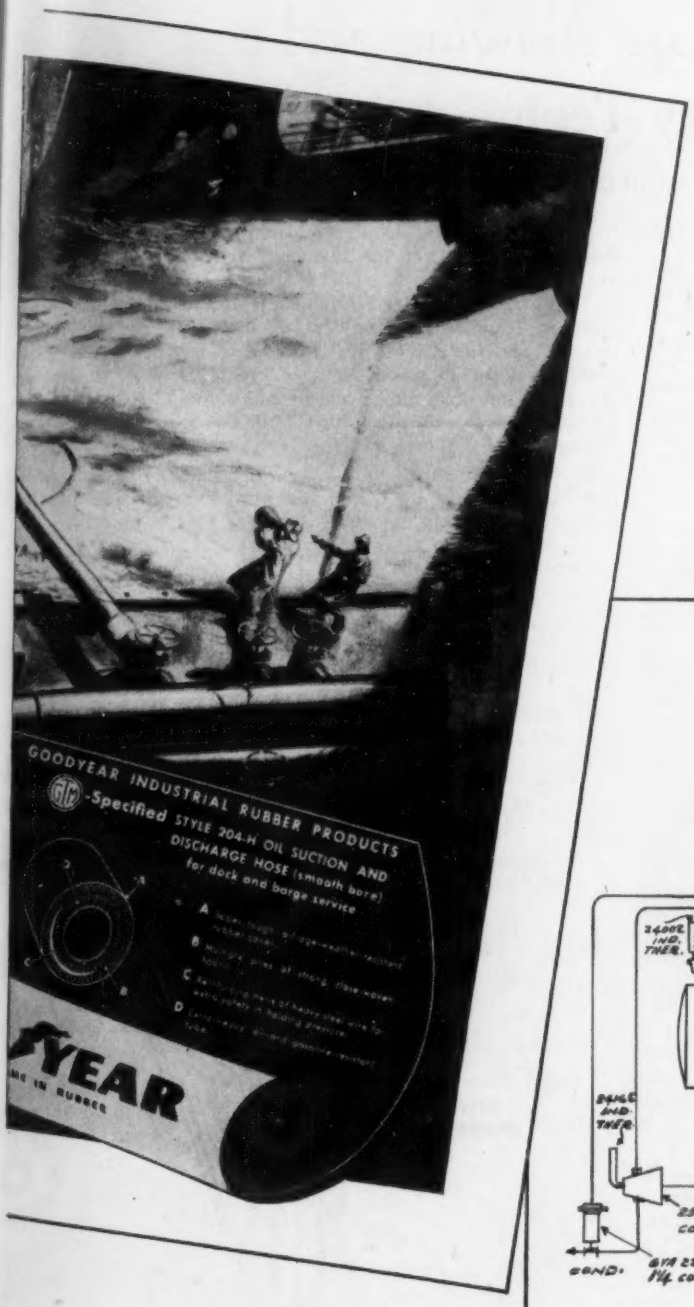
helped write this Goodyear Ad!

THIS recent Goodyear story in TIME told how a piece of 10-inch Goodyear oil suction and discharge hose had kept an oil tanker from being driven ashore.

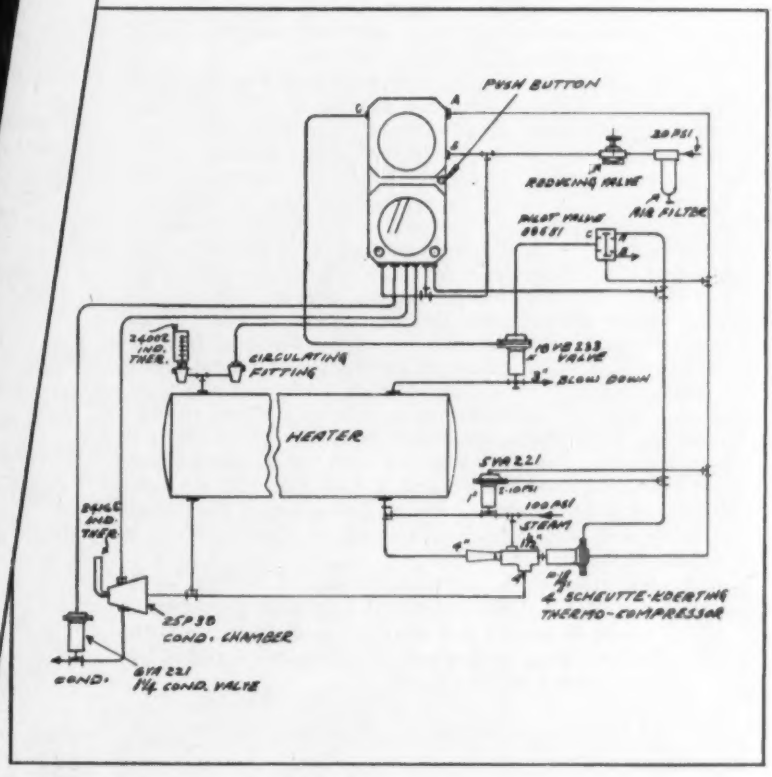
We take pride in reproducing this ad here because Taylor engineers helped Goodyear work out the vulcanizing setup that give these 50-foot lengths of hose their rugged, uniform built-in strength.

Our recommendations included the use of a thermocompressor controlled by a Taylor Fulscope Time-Schedule Temperature Controller. This arrangement (see sketch at right) provided the necessary heat distribution to assure uniform curing throughout. Incidents like this have proved the worth of this method of doing business.

Taylor Engineers and Taylor Instruments are faithfully serving the rubber industry in many ways . . . helping cure everything from hose to hot water bottles . . . making natural rubber behave and making synthetic rubber act natural . . . from raw material right through the copolymer plant to the finished product. In addition, Taylor Instruments are the brains, lungs, heart and a few other vital parts of hundreds of other automatic processes used in making everything from



● *This Goodyear Ad appeared in the December 3rd issue of Time Magazine. The oil hose it talks about was vulcanized by a process developed jointly by Goodyear and Taylor Engineers.*



chemicals to high octane gasoline. Not to speak of the gaseous diffusion process at Oak Ridge for which Taylor is prime contractor for process control instruments.

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Scientific Glass Blowing and Laboratory Techniques

By WILLIAM E. BARR and VICTOR J. ANHORN, Gulf Research & Development Company

VII. GROUND SURFACES FOR GLASS APPARATUS

The importance of ground glass joints, stopcocks and equipment containing ground glass surfaces can readily be visualized by inspecting a research laboratory. An inventory of all glass equipment will show that without stopcocks and ground joints the workers would encounter difficulty in the handling of gases and liquids. Certain basic equipment units when fitted with stopcocks and ground joints have been planned and constructed so that they can be altered for different uses by merely changing the auxiliary unit parts. Ground joints are ordinarily used in systems where it is desirable to remove parts of the total glass assembly for cleaning and for charging or removing liquids or reactants. They are also used as simple connectors between large and intricate parts of a glass reactor system, or as closures for volumetric glassware and reagent bottles. Stopcocks are used for controlling and directing gas traffic in closed glass systems or in controlling the flow of liquids.

The history of the development of stopcocks and ground glass joints need not be discussed. Producers of glass equipment and individual glass blowers developed techniques which progressed from a clumsy cone and socket to a precise unit indispensable in the production of modern laboratory equipment. It is interesting to note that the development of various laboratory techniques, among which vacuum technique was the most important, actually required that joints and stopcocks should be leak-proof. Another development which influenced the production of more flexible laboratory equipment was the standardization of some joints and stopcocks. Under the guidance of the National Bureau of Standards, a standard taper was voluntarily established by mutual consent of producer, distributor and the consumer. Joints and stopcocks made according to the specifications set forth in Commercial Standard CS 21-39[1] are interchangeable. These are stamped with the standard taper mark combining the letters S and T (see Fig. 71). No definite type of glass is specified for the production of the standard joints and stopcocks. The general requirements given in CS 21-39 are as follows:

1. All interchangeable joints, stopcocks and stoppers shall have a taper of 1± 0.006 mm/cm of length on diameter.
2. All joints, stopcocks and stoppers shall be made with standardized working tools checked with gages certified by the National Bureau of Standards.
3. All master gages used in the production of interchangeable joints, stopcocks or stoppers must be made of tool steel, hardened and ground.

The detailed requirements for joints, stopcocks and stoppers are also given and Commercial Standards CS 21-39 should be consulted if information is required.

Ground Joints

The standard ground joint is shown in Fig. 57. The inner and outer members of the joint have a tubing diameter which corresponds approximately to the outside diameter of the small ground end of the inner member of the joint. Due to this tube-size ratio, small joints when sealed to large flasks appear ridiculously fragile and out of proportion. Large tubing cannot be sealed close to the joint because of the danger of warping the ground surface. It is advisable, however, to butt seal larger tubing to the outer member at a point approximately ¾" from the joint so as to offer some protection to the flask by having a larger tube sealed to it. With such an arrangement a break in the small tubing of the joint will not damage the flask.

The ground joint may be obtained with a ground section in one of three different lengths. The full-length ground joint which is the most popular is made in sizes ranging from 5 to 71 mm. approximate diameter at the large end of the ground zone. The medium-length joint sizes are from 5 to 40 mm., while the short-length joints range from 10 to 71 mm. The standard dimensions for all three joints are given in Table 4. The listed sizes correspond to two dimensions of the joint. The first number indicates the approximate diameter in millimeters of the large end, the second gives the length of the ground glass zone. The taper is 1 to 10 with the tolerances within ±0.006 mm./cm. length on diameter.

The complete taper joint may be purchased with four tying lugs or hooks by which the joint can be held together with rubber bands or small springs. If the hooks are required, they must be specified when joints are purchased. On occasions it may be necessary to attach hooks on plain joints. The following procedure is recommended:

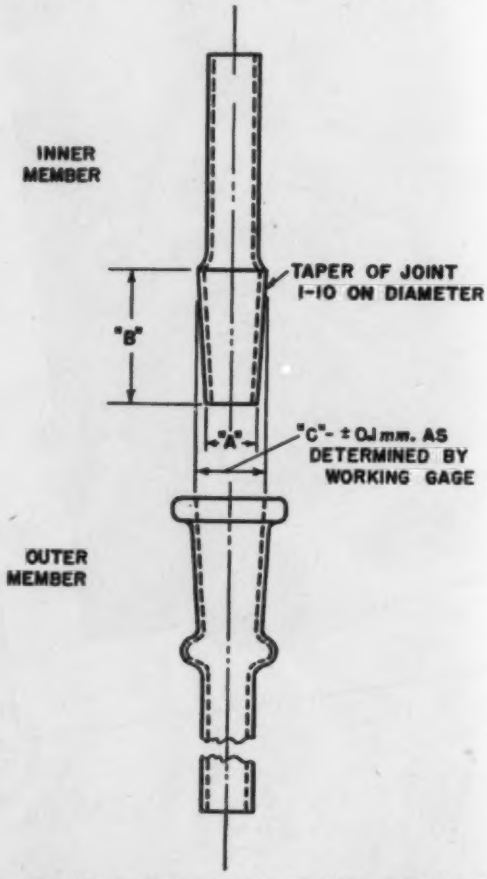


Fig. 57. *(Drawings by Richard P. Jones, Gulf Res. & Dev. Co.)*

1. In operations where it is necessary to heat the glass sufficiently to fuse and flow the two glass parts together, one is sometimes hindered by the bright glare of the yellow sodium flame. Didimium or Neophan spectacles or goggles are recommended to filter out the sodium glare and allow visibility in all operations where the glass is heated. A 5 mm.-diameter glass rod is used in making the hook. The end of the rod and the tube are heated until the glass is fused sufficiently to flow together when the two fused surfaces are contacted. If the glass is not heated sufficiently and the lugs are attached as in Fig. 58B they will snap off under strain. The glass must be smoothly flowed together as shown in Fig. 58A. The glass rod, after it is attached, is bent back

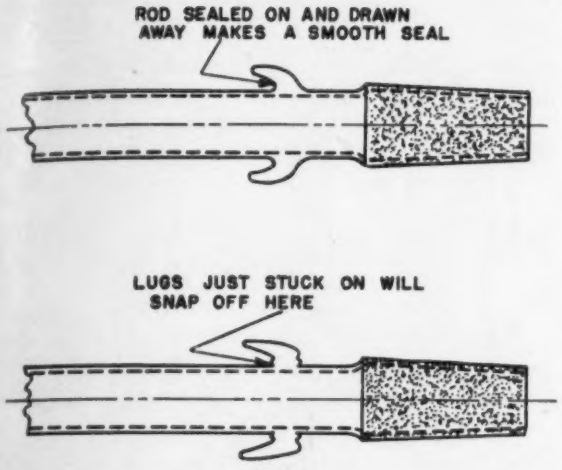


Fig. 58

parallel to the glass tube, drawn out, and cut off in the burner flame.

Spherical Ground Glass Joints

Another type of ground glass joint which finds use in fabricating scientific glass apparatus is the ball and socket or spherical joint. These joints lessen the risk of breakage because they need not be perfectly aligned as in the case of taper joints. If spherical joints are lubricated properly they may be moved when the system to which they are sealed is under vacuum. The taper joint has a greater tendency to stick, especially if it is not lubricated properly.

The size of a spherical joint is designated by its number. The first gives the inside diameter of the tubing in millimeters. The second number designates the diameter of the ball. The available sizes of spherical joints are given in Table 5.

TABLE 4—SPECIFICATIONS AND DESIGNATIONS FOR STANDARD TAPER INTERCHANGEABLE GROUND JOINTS

(Taper, 1 to 10; i.e., one mm. ± 0.006 mm. per centimeter of length on diameter)

Designation (Large Diam./ Length of Ground Zone)	Computed Diam. Large End of Ground Zone	Approx. Diam. Small End of Ground Zone
mm.	mm.	mm.
FULL-LENGTH JOINTS		
5/20	5.0	3
7/25	7.5	5
10/30	10.0	7
12/30	12.0	9
14/35	14.5	11
19/38	18.8	15
24/40	24.0	20
29/42	29.2	25
34/45	34.5	30
40/50	40.0	35
45/50	45.0	40
50/50	50.0	45
55/50	55.0	50
60/50	60.0	55
71/60	71.0	65
MEDIUM-LENGTH JOINTS		
5/12	5.0	3.8
7/15	7.5	6.0
10/18	10.0	8.2
12/18	12.0	10.2
14/20	14.5	12.5
19/22	18.8	16.6
24/25	24.0	21.5
29/26	29.2	26.6
34/28	34.5	31.7
40/35	40.0	36.5
SHORT-LENGTH JOINTS		
10/10	10.0	9.0
12/10	12.0	11.0
14/10	14.5	13.5
19/10	18.8	17.8
24/12	24.0	22.8
29/12	29.2	28.0
34/12	34.5	33.3
40/12	40.0	38.8
45/12	45.0	43.8
50/12	50.0	48.8
55/12	55.0	53.8
60/12	60.0	58.8
71/15	71.0	69.5

TABLE 5—BALL-AND-SOCKET GROUND GLASS JOINTS

Size Designation	Diam. of Ball, mm.	Approx. I.D. of Tube, mm.
*12/1	12	1
*12/1½	12	1½
*12/2	12	2
12/3	12	3
12/5	12	5
18/7	18	7
18/9	18	9
28/11	25	11
28/12	25	12
35/20	35	20
35/25	35	25
50/30	50	30
65/40	65	40

Note:—Items marked (*) are made of capillary tubing.

It is generally necessary to clamp spherical joints together. Metal clamps are marketed by Ace Glass Company, Inc. Clamp and joint are shown on the right in Fig. 59. Clamp sizes are 12, 18, 35, 50 and 65 and are used with joints with the corresponding ball sizes. Another useful clamp, shown on the left in Fig. 59, is sold by the Arthur H. Thomas Company.

Experience in the laboratory showed that more spherical joints are broken by improper clamping than by any other cause. Some consideration must be shown whenever pressure

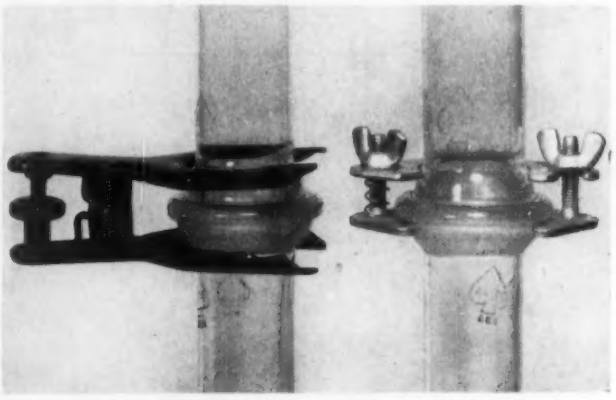


Fig. 59

is being applied to the glass. One should never attempt to seal a leaky spherical joint by increasing the pressure on the joint with the set screws of the clamp. Usually the leak is caused by improper lubrication or by small dirt particles which were not removed before the joint was assembled.

Sealing Joints to Glass Equipment

Joints usually are sealed to straight tubing or flasks, and before the joints are sealed, they should be cleaned thoroughly. A small reagent bottle of carbon tetrachloride, chloroform or benzene should be kept on the reagent shelf for cleaning joints and stopcocks. A small glass holder wrapped with asbestos tape is pressed into the joint and the latter is aligned for minimum wobble during rotation. The joint is sealed to straight tubing by the simple butt sealing technique. Round-bottomed flasks can be purchased with attached joints but sometimes it is necessary to replace a broken joint or to seal a joint to a balloon flask which has the conventional opening. Flask holders, obtainable from various companies which supply glass-working equipment, come in various sizes and are simple in design. Four metal bands or flexible rods are attached to one end of a round handle. These bands or rods which are 90° apart extend around the flask and are held against the latter by the tension in the rods, or by a wire coil spring which is hooked under each end of the bands. The flask can then be held in one hand and rotated during the sealing process. The procedure for preparing the opening in the flask will depend on the tubing size of the neck: usually between ½" and 2". The neck is either cut and used as such or it must be drawn down to the diameter of the joint tubing. Simple butt sealing, of equal-diameter tubes and of tubing of different sizes, has

been described and the same procedure can be used here. Some practice in balancing and rotating the flask is required, especially if the flask is large. Large flasks must be supported on the rollers.

Adapters which consist of two different sized joints (inner joint of one size sealed to the outer joint of another size) are sometimes needed. Any combination of sizes can be made by butt sealing two different joint parts together.

Stopcocks

Stopcocks of simple or special designs are made up in two parts. The shell or barrel—the outer member to which are connected the outlet tubes—has a tapered inner ground surface. The second part—the ground plug or inner member—fits into the barrel. The plug is drilled so that the bore hole serves as a connecting link between the respective outlet tubes.

The standard straight-bore stopcock is described, and the production requirements are given in Commercial Standards CS 21-39. It is shown in Fig. 60. The taper of the barrel or shell is 1± 0.006 mm./cm. on diameter (1-10). The number, diameter of plug at the center line of the bore hole, length of shell and diameter of the bore hole in the plug of the various sizes of the standard straight bore stopcock are given in Table 6. The manufacturers of this stopcock have added one improvement by grinding a groove in the small end of the plug for retaining keys or rubber rings. This standard stopcock is not recommended for vacuum apparatus or liquids with low densities.

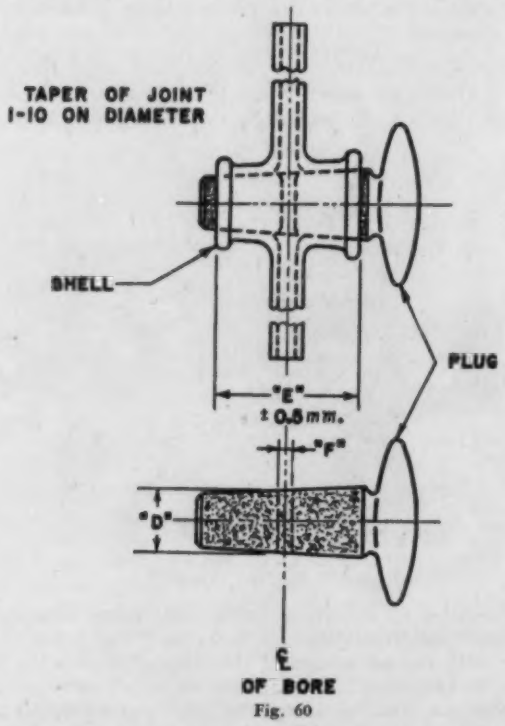


Fig. 60

Many other forms of stopcocks available from various manufacturers are not standardized. The frequently-used oblique-bore stopcock is supplied with a single bore, or double bore for a three-way stopcock. The tee or 120° types have three outlet tubes and are useful for gas traffic control. Numerous innovations, such as plugs with outlets through the small end or mercury seal cups, have been incorporated in stopcocks. In *Bureau of Standards Circular C 430*, Martin Shepherd[2] has attempted to stir the imagination of the laboratory technician in designing single stopcocks which take the place of several conventional single-bore types.

Sealing Stopcocks to Glass Equipment

Stopcocks are sealed to glass equipment by using the simple butt-sealing technique. Three things should be kept in mind when seals are made:

1. The stopcock plug is removed and the barrel cleaned thoroughly to remove all grease.

TABLE 6—STANDARD DIMENSIONS FOR INTERCHANGEABLE STRAIGHT-BORE GROUND-GLASS STOPCOCKS

Standard Stopcock Number	Diameter of plug at center line of bore	Length of shell ±0.5 mm.	Diameter of bore hole in plug
	D	*E*	*F*
	mm.	mm.	mm.
1	12	30	1
1½	12	30	1½
2	12	30	2
3	17	40	3
4	17	40	4
5	20	44	5
6	20	44	6
8	25	52	8
10	35	56	10

2. The open ends of the barrel are plugged with corks. Since it is necessary to balance the stopcock, one should use corks of the same size. The larger opening in the barrel is closed by inverting one cork and pushing the large end of it into the barrel so that both corks are about equidistant from the outlet-tube center line.

3. The seal must not be made close to the stopcock barrel. Experience has shown that at least ¾" should be allowed between the barrel and the seal.

The stopcock is sealed to glass tubes or equipment parts by the various techniques previously described. When seals are made by hand in a burner flame, the outlet tube is used as a handle for rotating the stopcock.

Production of Standard Taper Joints and Stopcocks

The commercial production of joints and stopcocks has been satisfactory and it is only occasionally that a joint or stopcock which is to be used for routine work in the laboratory must be rejected. There are times, however, when such joints must be repaired by regrinding. Furthermore, the development of the technique in making joints and stopcocks will be helpful when special joints or stopcocks are required which cannot be purchased. Stopcocks for vacuum systems must also be ground to closer tolerances to be satisfactory.

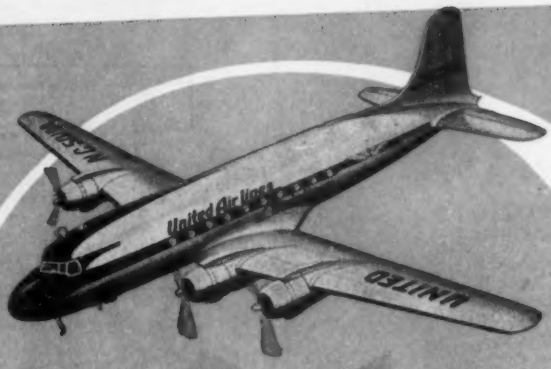
Tools Required for Making Joints and Stopcocks

The tools necessary for the shaping and grinding of glass are shown in Fig. 61. Three sets are shown each of which consists of a standard hexagonal taper reamer, taper grinder, taper grinding sleeve which fits over the taper grinder, taper socket and a taper grinding sleeve which fits into the taper socket. The socket on the right was designed for shallow tapers. It is split so that the grinding sleeve can be easily removed.

Fig. 61

The standard carbon hexagonal reamers can be purchased from any company which markets glass-blowing supplies. Suitable handles may be obtained for each set. Steel hexagonal taper reamers, which can be made if shop facilities are available, are shown in Fig. 62. They are made of steel and are lightened by boring out the center. These reamers are unbreakable and will not wear. The dimensions for the four standard taper reamers are given in the dimensions log in Table 7. Beeswax should be used as a lubricant when hot glass is worked with the metal reamers.

Grinding tools cannot be purchased but are easily made if machine shop facilities are available. The drawings for



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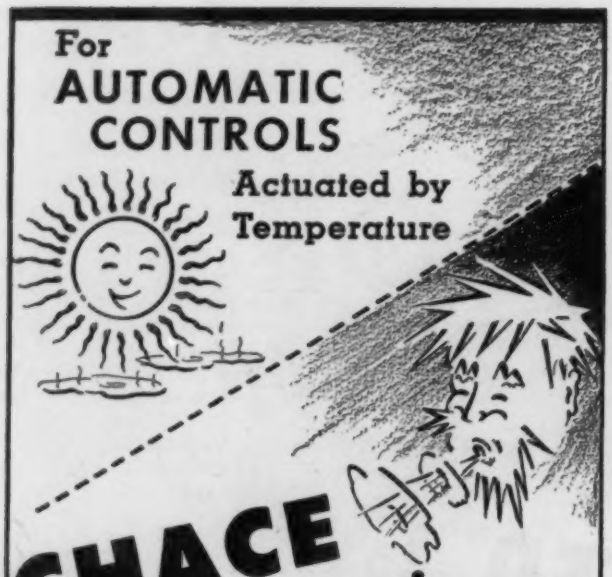

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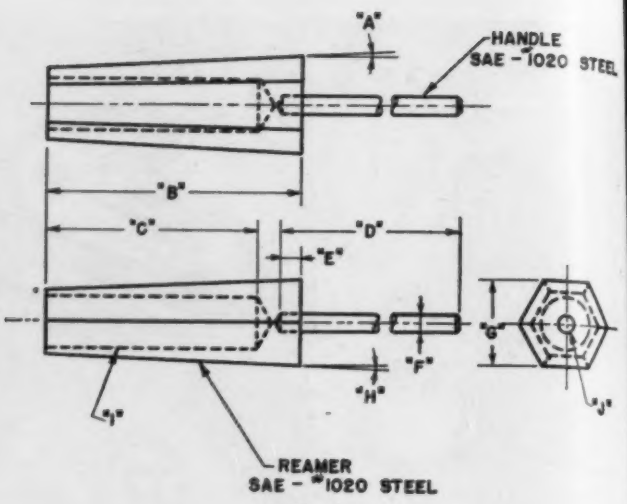

Fig. 62

TABLE 7—STANDARD TAPER REAMER

"A"	"B"	"C"	"D"	"E"
2°52′±2′	6″	—	8″	1/2″
2°52′±2′	6″	5″	8″	1/2″
2°52′±2′	6″	5″	8″	1/2″
2°52′±2′	6″	5″	8″	1/2″

"F"	"G"	"H"	"I"	"J"
3/8″	0.625″±0.003″	2°29′	—	3/8″
5/8″	1.088″±0.003″	2°29′	5/8″	5/8″
5/8″	1.543″±0.003″	2°29′	5/8″	5/8″
5/8″	2.000″±0.003″	2°29′	1 1/4″	5/8″

the standard long taper grinder and socket with their respective sleeves are given in Fig. 63. The log of the dimensions for three different sets is given in Table 8. The grinding tools are made of brass with rolled tinplate as sleeves. Basically this set of grinding tools is designed for long tapers and for all the taper sizes between the extreme dimensions. There are occasions, however, when short tools are required. The drawings for this set are given in Fig. 64. A log of all critical dimensions is given in Table 9. This set of grinding tools covers a large range of sizes, the smaller sizes being quite useful in making joints and stopcocks for microchemical equipment. This latter set is made of 18-8

TABLE 8
STANDARD TAPER GRINDING SOCKET AND SLEEVE (LONG)

Socket Dimensions

"A"	"B"	"C"	"D"
1 1/4″	0.375″ ±0.002″	6″	2°52′±2′
1 5/8″	0.8125″±0.002″	6″	2°52′±2′
2 1/8″	1.250″ ±0.002″	6″	2°52′±2′

Sleeve Dimensions

"E"	"F"	"G"	"H"
18°	3.75″ ±0.010″	6.007″±0.010″	9.757″±0.010″
18°	8.125″±0.010″	6.007″±0.010″	14.132″±0.010″
18°	12.5″ ±0.010″	6.007″±0.010″	18.507″±0.010″

STANDARD TAPER GRINDER AND SLEEVE (LONG)

Grinder Dimensions

"A"	"B"	"C"	"D"	"E"	"F"
0.9375″±0.002″	2°52′±2′	3/4″	1″	6″	7″
1.375″ ±0.002″	2°52′±2′	3/4″	1″	6″	7″
1.8125″±0.002″	2°52′±2′	3/4″	1″	6″	7″

Sleeve Dimensions

"G"	"H"	"I"	"J"
18°	3.368″±0.010″	6.007″±0.010″	9.375″±0.010″
18°	7.743″±0.010″	6.007″±0.010″	13.750″±0.010″
18°	12.118″±0.010″	6.007″±0.010″	18.125″±0.010″

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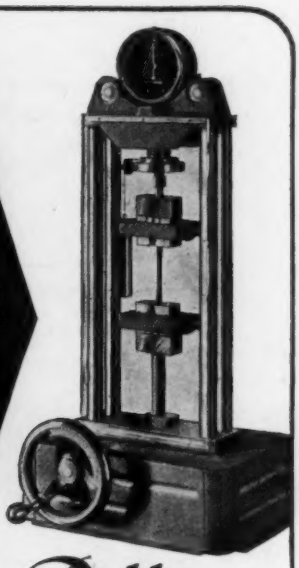

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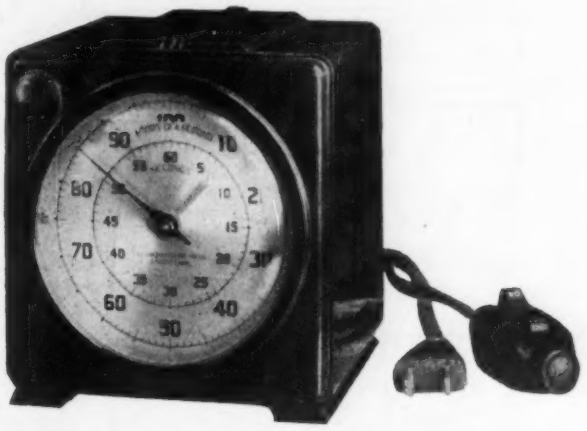

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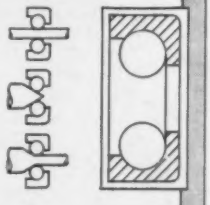

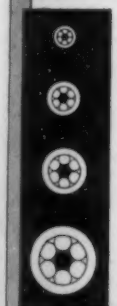

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stainless steel and sleeves for the smaller sizes are made of thin copper sheet.

Production of a Standard Taper Joint

The most difficult operation in making a joint or stopcock is the shaping of the glass of both the outer and inner members. A certain amount of glass must be gathered for building up the wall thickness in the sections that are ground. If the wall thickness is not increased the joint will be quite fragile because of the grindaway of glass. The required tools for making a joint or stopcock are a standard

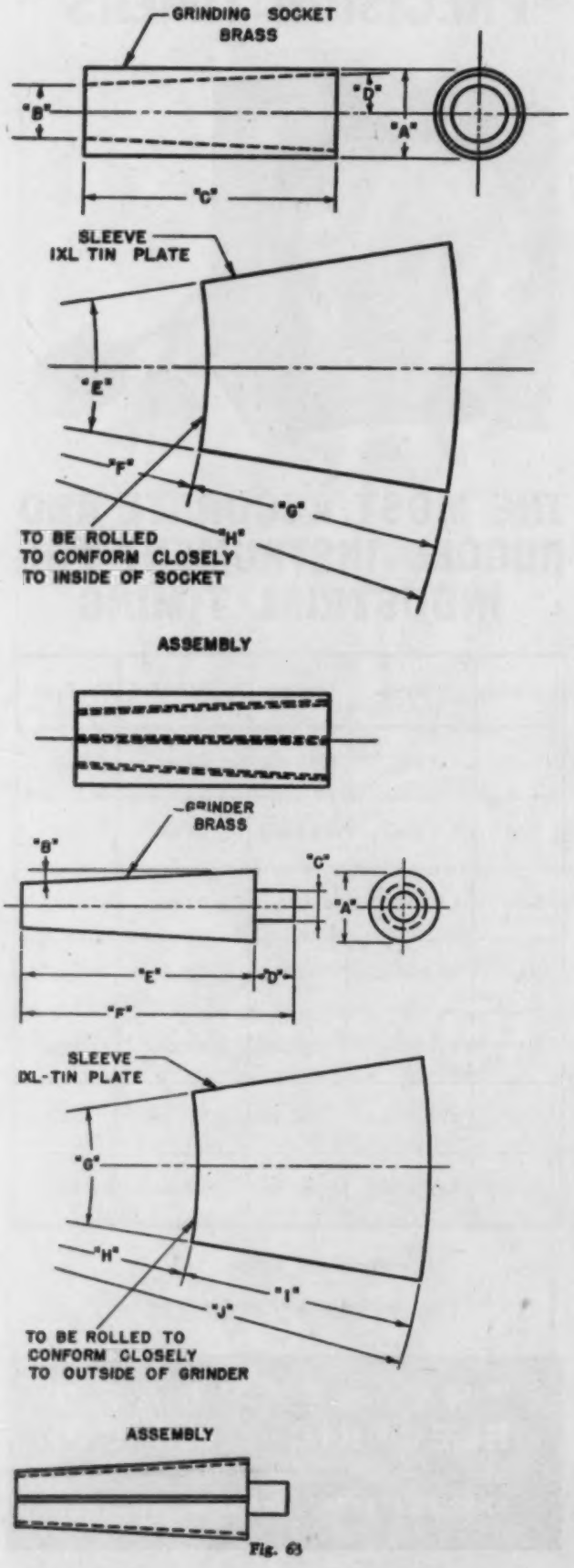

Fig. 63

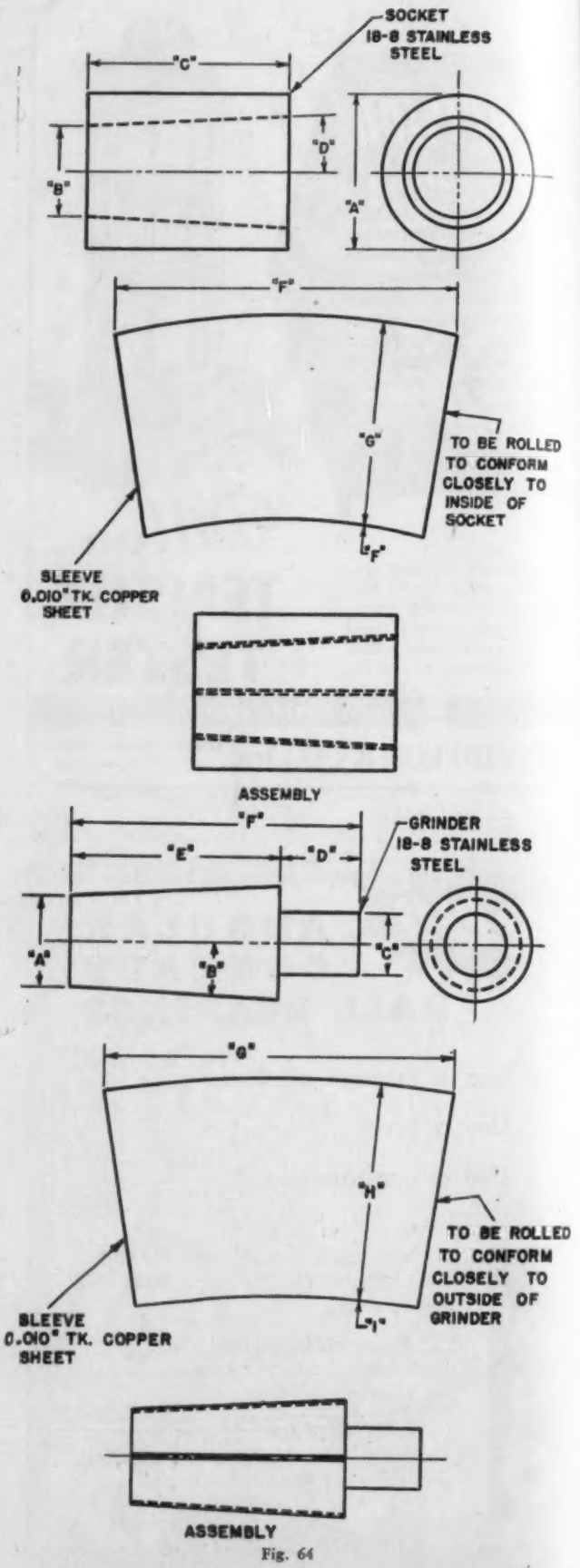

Fig. 64

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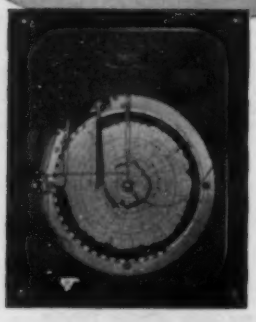

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TABLE 9
STANDARD TAPER GRINDING SOCKET AND SLEEVE (SHORT)

Socket Dimensions

No.	"A"	"B"	"C"	"D"
5	$\frac{3}{4}$"	0.178" ± 0.001"	$1\frac{13}{16}$"	2° 52′ ± 2′
7	$\frac{3}{4}$"	0.257" ± 0.001"	2"	2° 52′ ± 2′
9	1"	0.335" ± 0.001"	2"	2° 52′ ± 2′
11	1"	0.414" ± 0.001"	$2\frac{1}{16}$"	2° 52′ ± 2′
15	$1\frac{1}{4}$"	0.571" ± 0.001"	$2\frac{1}{16}$"	2° 52′ ± 2′
30	2"	1.162" ± 0.001"	$2\frac{5}{16}$"	2° 52′ ± 2′
65	$3\frac{1}{4}$"	2.540" ± 0.001"	$3\frac{1}{4}$"	2° 52′ ± 2′

Sleeve Dimensions

"E"	"F"	"G"
1.083" ± 0.001"	$1\frac{11}{16}$"	1.815" ± 0.002"
1.389" ± 0.001"	$2\frac{11}{16}$"	2.003" ± 0.002"
1.633" ± 0.001"	$3\frac{1}{4}$"	2.003" ± 0.002"
1.939" ± 0.001"	$4\frac{3}{16}$"	2.190" ± 0.002"
2.468" ± 0.001"	$5\frac{5}{16}$"	2.315" ± 0.002"
4.416" ± 0.001"	$11\frac{11}{16}$"	2.628" ± 0.002"
8.923" ± 0.001"	$25\frac{11}{16}$"	3.254" ± 0.002"

STANDARD TAPER GRINDER AND SLEEVE (SHORT)

Grinder Dimensions

No.	"A"	"B"	"C"	"D"	"E"	"F"
5	0.138" ± 0.001"	2° 52′ ± 2′	$\frac{1}{2}$"	1"	$1\frac{13}{16}$"	$2\frac{11}{16}$"
7 & 9	0.217" ± 0.001"	2° 52′ ± 2′	$\frac{1}{2}$"	1"	$2\frac{3}{16}$"	$3\frac{3}{16}$"
11	0.374" ± 0.001"	2° 52′ ± 2′	$\frac{1}{2}$"	1"	$2\frac{5}{16}$"	$3\frac{5}{16}$"
15	0.531" ± 0.001"	2° 52′ ± 2′	$\frac{3}{4}$"	1"	$2\frac{5}{16}$"	$3\frac{5}{16}$"
30	1.122" ± 0.001"	2° 52′ ± 2′	$\frac{3}{4}$"	1"	$2\frac{5}{16}$"	$3\frac{5}{16}$"
65	2.500" ± 0.001"	2° 52′ ± 2′	$\frac{3}{4}$"	1"	$3\frac{1}{4}$"	$4\frac{1}{4}$"

Sleeve Dimensions

"G"	"H"	"T"
1.027" ± 0.001"	1.815" ± 0.002"	$1\frac{11}{16}$"
1.561" ± 0.001"	2.753" ± 0.002"	$2\frac{11}{16}$"
1.895" ± 0.001"	$2\frac{1}{4}$"	$3\frac{11}{16}$"
2.453" ± 0.001"	$2\frac{5}{16}$"	$5\frac{11}{16}$"
4.368" ± 0.001"	$2\frac{11}{16}$"	$11\frac{11}{16}$"
8.880" ± 0.001"	$3\frac{7}{16}$"	$25\frac{7}{16}$"

taper scale, Fig. 65C, three calipers, a standard taper reamer, a round carbon tool, a flat carbon tool, standard taper grinding socket with two sleeves, a standard taper grinder with two sleeves, grinding carborundum grit numbers 220, 320, 600 and Turkish emery SF-10.

As an example, suppose a size 24/40 joint is to be made. From the detail requirements given in Table 4 the glass tubing must have an approximate diameter of 20 mm. The inner member when finished has a ground section 40 mm. long. The diameters of the ground sections at the small or

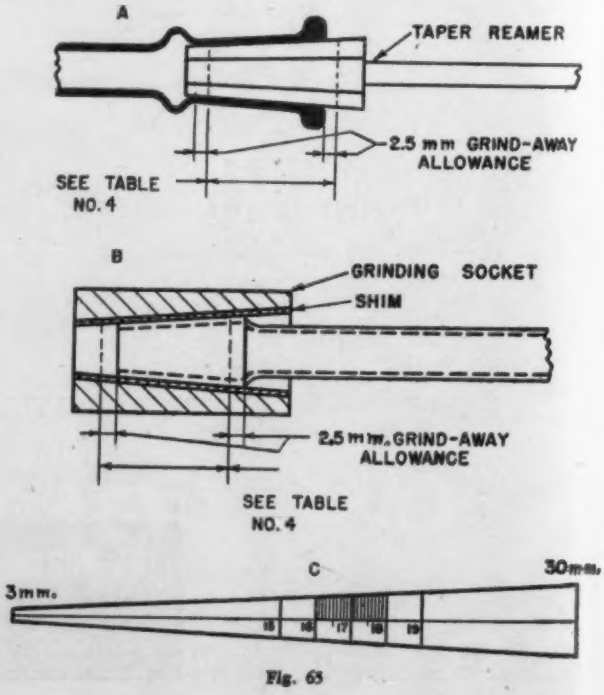
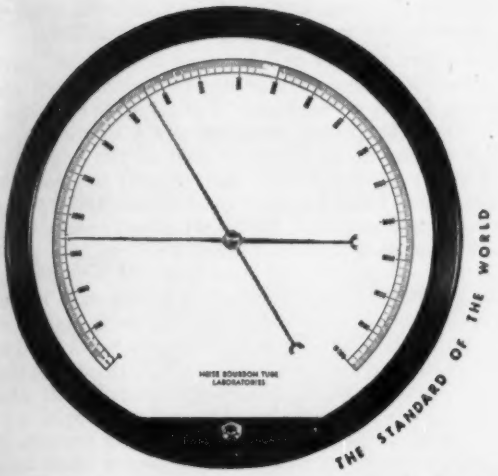


Fig. 63



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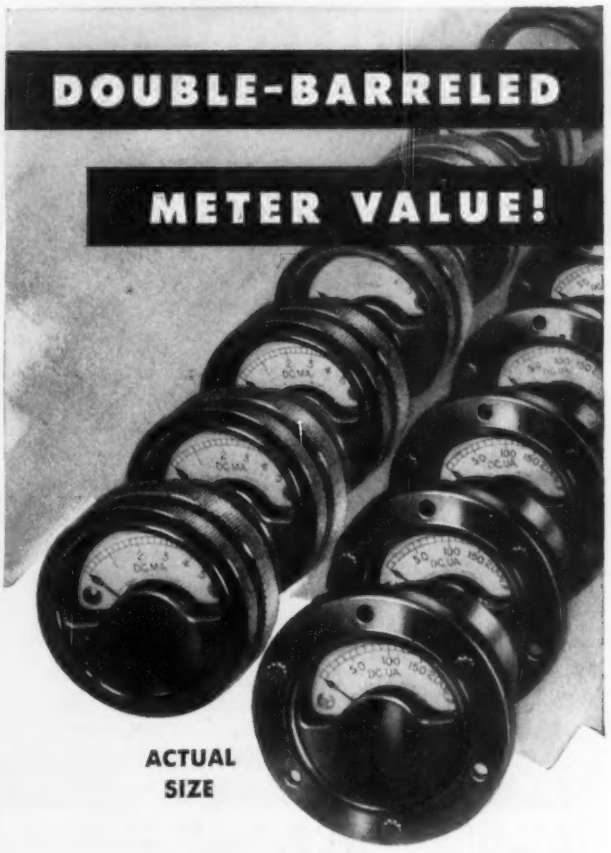

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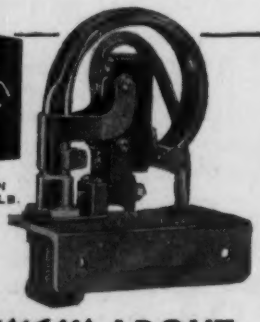

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open end and the large end are 20 and 24 mm. respectively. The procedure for making the joint is as follows:

1. The outer member will be made first. A 14" section of approximately 20 mm. tubing is chosen from stock and two points are drawn on each end. The point held in the right hand is closed by fusing the glass and a blowing tube with swivel is connected to the point held in the left hand. The tube is then heated over a 3" section near the point held in the right hand. The glass is allowed to accumulate by fusion under continued rotation. As the glass collapses it is blown out to the original tube diameter. Two motions are necessary in this operation: the tube must be rotated for even heating and must be moved along the horizontal to heat the 3" section. This operation of gathering the glass will require considerable practice. The tube must not be twisted and an attempt should be made to keep the wall thickness the same over the heated section. After the desired wall thickness has been obtained, the tube is then heated over a ½" circular section of thickened glass end which is nearest the left hand and at the point where the thickened glass meets the original glass tube. This section is then blown out to a bulb with a diameter ¼" greater than the original tubing. This bulb is shown in Fig. 57. The wall thickness of the bulb will be comparable to that of the original tubing because of the accumulation of glass at that point.

The open end of the joint is made next. The ground section of the joint is to be 40 mm. in length; therefore, at least 44 mm. of glass from the base of the bulb to the end is required for the ground section and the round beaded end of the outer member. A chalk mark or very small file mark is made at a point 44 mm. from the base of the bulb and the glass is cut in the burner flame. The excess glass is drawn away and the tip is heated until the glass is fused back to the mark. The fused glass is blown to a thin bulb which is scraped away with forceps. At this point the reamer which is to be used must be calipered and marked. The dimensions are obtained from the taper scale. A vernier caliper is moved along the scale until the scale cross-section measurement of 24 mm. is obtained. This is to be the finished diameter at the top of the joint. However, a certain amount of grinding must be done before this final diameter is reached, so a certain length along the scale must be allowed. A satisfactory grindaway is about 2.5 mm., so the vernier caliper is moved down the scale 2.5 mm. The diameter at this point is smaller than 24 mm. (It should be pointed out here that the 2.5 mm. is a measurement along the horizontal and not along the taper of the scale.) The diameter of the scale is obtained and the reamer is marked at this diameter. The thickened glass is then heated around the opening and, when the glass begins to sag or flow slightly, the tube is removed from the flame and the reamer is inserted and turned in the direction opposite to that in which the tube is turned. The direction is reversed after each partial turn. The reamer must not be forced or pushed too tightly into the glass. The tube is again heated but this time it is important that the section where the taper ends be heated as well as the glass that has been tapered. This process is repeated until a true taper is obtained to the base of the cone. Sometimes it is necessary to smooth out the outside of the taper. This is accomplished by heating the glass and using a flat carbon tool. The reamer must be used after each smoothing operation. The end of the taper is then heated and the thickened glass is tooled to a form as shown in Fig. 65A. After the end is completed, the taper is enlarged until the end of tube is in line with the mark on the taper, Fig. 65A. After a thorough annealing the taper is now ready for grinding and has the required grindaway allowance of 2.5 mm., Fig. 65A.

The Inner Member

The inner member is made from the same tubing used in forming the outer member. A point is pulled on both ends of the tube which is 14" in length. While the glass points are allowed to cool, three calipers should be set by using the scale as a gage. The outer member was made undersize for grindaway allowance and for a similar reason the inner member must be made oversize. The 24 mm. point on the

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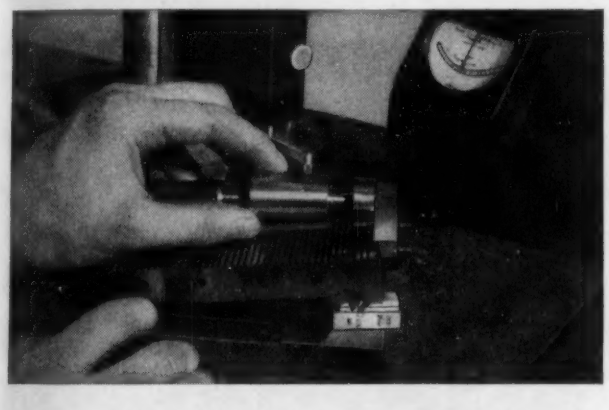

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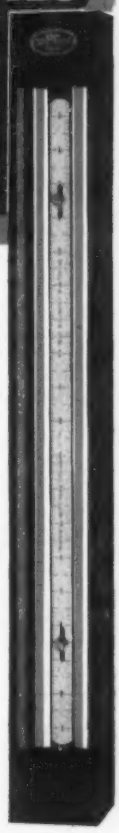

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scale is recorded and one caliper is set for a diameter 2.5 mm. toward the wider end of the scale. This point will be designated as number 1. The second caliper is set at 40 mm. The third caliper is set at the diameter of the scale 40 mm. from point 1.

The inner taper is more difficult to make because it must be shaped by hand. The glass tube is heated with rotation at a point 3" from the right tube end. Enough glass is collected for a heavy-walled shoulder to be blown.

After the shoulder is blown the glass from this shoulder to within ½" of the end of the tube is heated and glass is accumulated beyond the shoulder to the end. The glass is collapsed and blown out to the tube diameter on one end and the diameter of the shoulder on the other. Imperfections such as small bulges are smoothed down with a flat carbon tool. As the glass is collected, the taper is formed by pulling down the expanded section. One must be careful to do this slowly, *i.e.*, the glass accumulation must be faster than the pulling-down operation since the wall thickness is decreased by the latter operation. As the taper forms, one should caliper the diameter of the two ends, the diameters

Fig. 66

at the shoulder and 40 mm. below the shoulder. After these diameters have been obtained, the taper is cut at the point 40 mm. from the shoulder either by the burner or cutting wheel. When the former method is used, the end will have to be tooled smooth with a round and a flat carbon tool. Wheel cuts should be fire polished. In production work this inner joint is also tooled.

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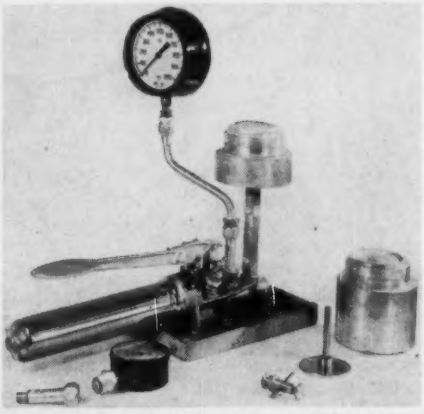

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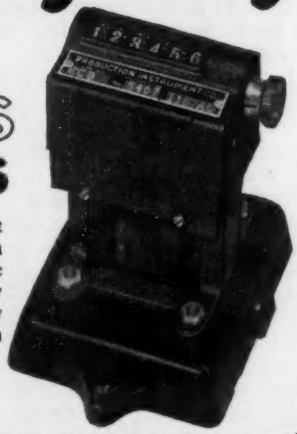

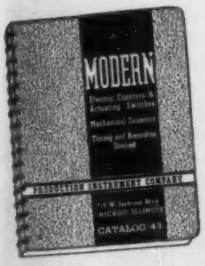

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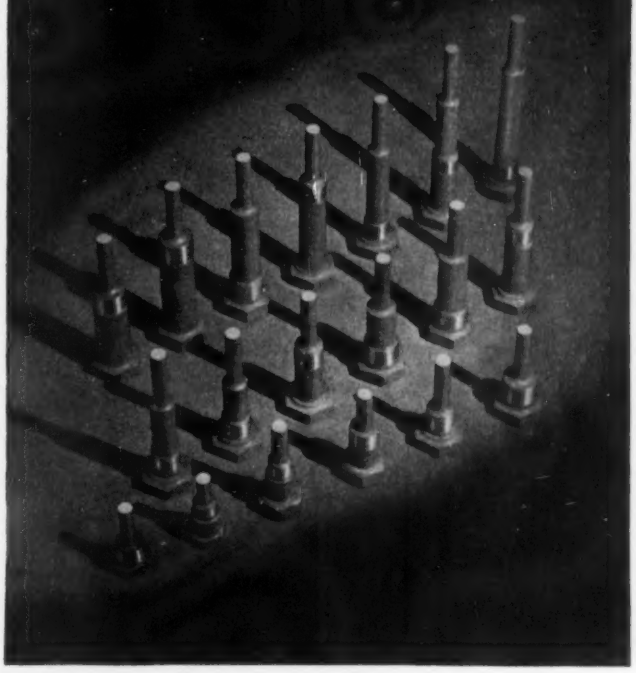

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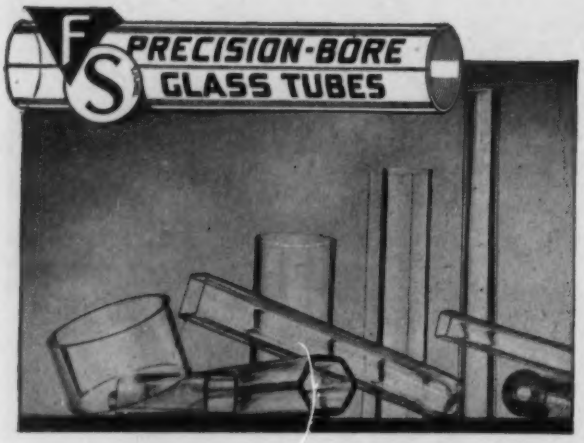

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duced to 100 r.p.m. by a pulley arrangement. The three-jaw chuck is fastened to the arbor of the pulley. The taper is centered in the chuck and the grinding sleeve is fastened to the taper with tape. A mark is made on the taper sleeve at the point where the diameter is 24 mm. Carborundum grit No. 220 is then mixed with water and applied to the joint and taper with a spatula. The motor is started and the joint is held against the grinding taper. One must be very careful that the ground surface is always wet.

As the grinding proceeds the cutting sound will diminish, indicating that another application of the carborundum grit and water mixture is needed. The ground surface should be examined before each application. Most of the cutting is done with No. 220 grit. The sleeve and joint should then be washed free of the coarse grit and the grinding is continued with carborundum No. 320 in water. This finer grit works into the soft metal sleeve and creates a planing action which begins to smooth out the marks caused by the coarser grit. When the mark in the sleeve coincides with the open end of the outer member, a new sleeve is put on the taper and the joint is thoroughly washed. Carborundum grit No. 600 in water is then used. The new sleeve will permit the production of a more accurate taper. The joint is ground until the correct diameter is obtained. It is then thoroughly washed and finished with Turkish emery SF-10.

The inner member is ground in the same way except that a grinding socket is used in the chuck. The grind-away allowance is determined as shown in Fig. 65B. The diameter of the shoulder on the joint should be measured periodically during the last stage of the grinding process. A complete joint, ground as just described will be interchangeable if made correctly. If a vacuum-tight joint is desired, it is necessary to grind the inner and outer members *together* with 600 carborundum, then Turkish emery SF-10 or No. 900 mesh grit. This procedure destroys the interchangeable character of the joint.

Making Stopcocks

Stopcocks as shown in Fig. 60 are made up in two parts: the plug or inner member, and the shell or barrel which constitutes the outer member. In the fabrication of a stopcock, two glass surfaces must be shaped and ground much in the same manner as in making ground joints. There are, however, two additional features which lead to complications if one is not careful in critical construction details. First, two inlet tubes must be sealed to the barrel and, secondly, the plug bore must be exactly aligned with the outlet tube openings. The procedure for making a stopcock is as follows:

1. The choice of tubing size for the barrel will depend upon the size of stopcock. As an example, suppose that a No. 2 standard taper stopcock is to be made. The standard dimensions of this stopcock as given in Table 6 show that the diameter of the plug at the center line of the bore is 12 mm., that the bore hole is 2 mm. in diameter and that the shell is 30 mm. long. The standard scale will be quite useful in choosing glass with a suitable tube diameter. The shell will be made undersize for grindaway. The diameter at the center line of the bore is obtained by setting a caliper at the diameter of the scale, 2.5 mm. along the scale horizontal line, from the 12 mm. diameter reading. This diameter will be smaller than 12 mm. since the 2.5 mm. distance was taken toward the point of the scale. This is the reference point from which the second point is established by measuring 15 mm. on the scale toward its base. The diameter at this point is set on a caliper which is used in setting and marking the diameter on a standard taper reamer. Measurement in the opposite direction will establish the diameter of the small end of the shell. The barrel should have a heavy wall because two outlet tubes must be sealed to it, and if the wall is thin there is more danger of deforming the tapered wall during the sealing. From the above measurement the diameter of the small end of the shell is about 10.5 mm. One must now choose glass tubing for the barrel. Any tube size from 12 to 18 mm. will be satisfactory but it is advisable to choose the latter. The diameter is worked down as the glass is gathered. Heavy-walled Pyrex combustion tubing 13 mm. O.D. is ideal in this case and is con-

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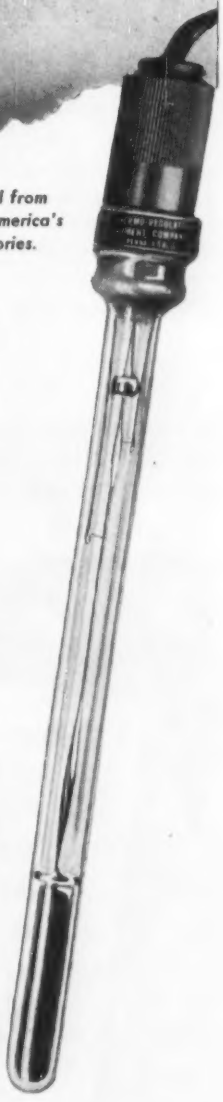

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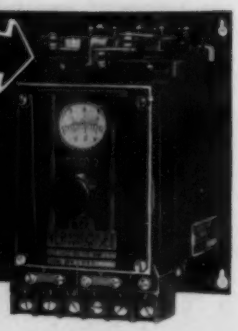

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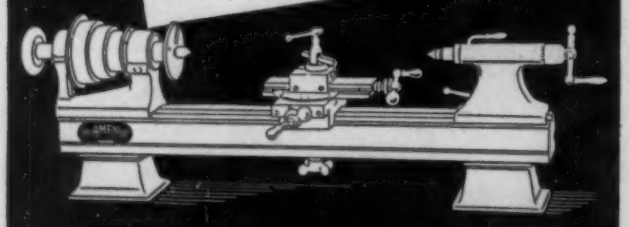

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veniently used when available. This thick-walled tubing eliminates gathering of glass. If ordinary Pyrex tubing is used, a section 12" long is taken from stock and a point is pulled on each end. The glass is then gathered and collapsed by fusing it in a cross fire. This procedure was outlined in the production of standard taper joints. The wall thickness of the glass is increased and the diameter is decreased. The glass must be kept smooth by blowing out slightly and working it down with a flat carbon tool. The glass tube is then opened by using the small burner flame.

2. The rough edge is tooled down by heating the end in the flame and using both a round and flat carbon tool. The reamer which has been marked at the desired undersize diameter is then used to form the taper. The same procedure should be used as was described under the preparation of a taper for the standard joint. After the taper is reamed to size, it is annealed and allowed to cool. The taper is then cut at the dotted line, Fig. 67A. The taper is then mounted on a glass holder and the small end is tooled to the shape shown in Fig. 67B.

3. The center line of the bore is then marked on the tapered shell. A 3 mm. glass rod is attached by touching the end of the glass rod which is fused in the burner, to the section of the shell which was marked and fused slightly at this mark. The glass holder is then removed and a spot *directly opposite* the point where the glass rod is attached,

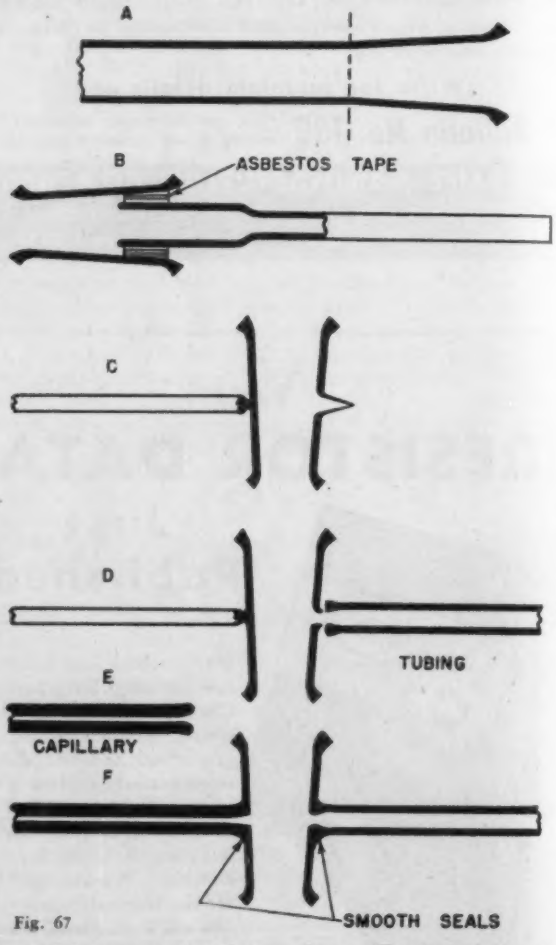

Fig. 67

is heated in a pin-point burner flame. The barrel is rotated by twirling the glass rod with the tips of the fingers. The glass is drawn out to a small cone by touching the fused glass with a glass rod, pulling the rod directly away from the shell, Fig. 67C. The thin cone is scraped away and the glass is fire polished to give a smooth round hole in the shell.

To be continued

REFERENCES

1. Commercial Standards CS 21-39, National Bureau of Standards, Wash., D. C. Interchangeable Ground-Glass Joints, Stopcocks and Stoppers, 4th Ed., Washington, U. S. Government Printing Office, 1939.
2. Martin Shepherd. Glass Stopcocks, Bureau of Standards Circular C-430, Washingon, U. S. Government Printing Office, 1941.

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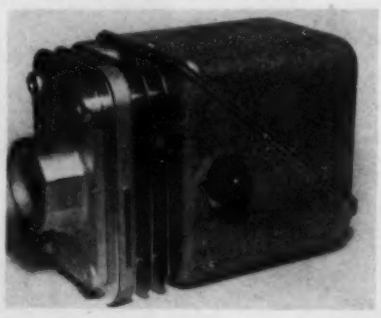
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department. Or write to Information Section, Instruments Publishing Company.

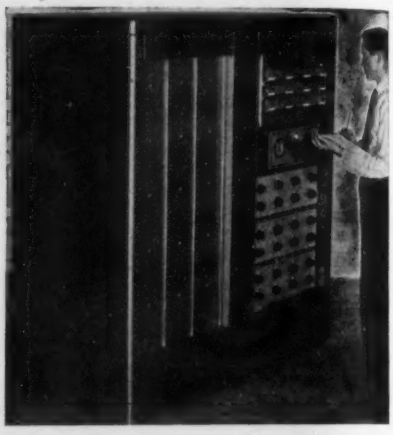
Photoelectric Flame Failure Safeguard

New "Type F 18 T Fireye Flame-Failure Safeguard" is designed to provide explosion protection for all industrial and commercial oil and pulverized coal burners. It consists of a phototube and amplifying system, housed in a dust-tight aluminum case. Entire control is mounted directly on the furnace wall and is aligned in a manner which permits phototube to observe flame through a 2" pipe connection which serves as both a sighting tube and a support for equipment. A clear Pyrex filter keeps equipment dust-tight and is mounted on a hinged shutter which permits it to be cleaned without shutdown. A heat-absorbing filter in the lens system as well as an efficient baffle system protect phototube from radiant heat. Phototube permits operation at high ambient temperature. Other features include a pilot light which can be viewed through an angle of 180°, and a time delay element which prevents relay from dropping out during purely transient flame disturbances. Supply: 115-230 volts 50/60 cycle a.c. Power consumption: 10 watts. Output: s-p.s-t relay. Contact: 5 amperes or ½ hp. at 230 volts a.c. Weight: 12½ lbs. Ambient temperature range: 32°F. to 150°F.—*Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.*



Direct-reading 12-line Analytical Spectrometer

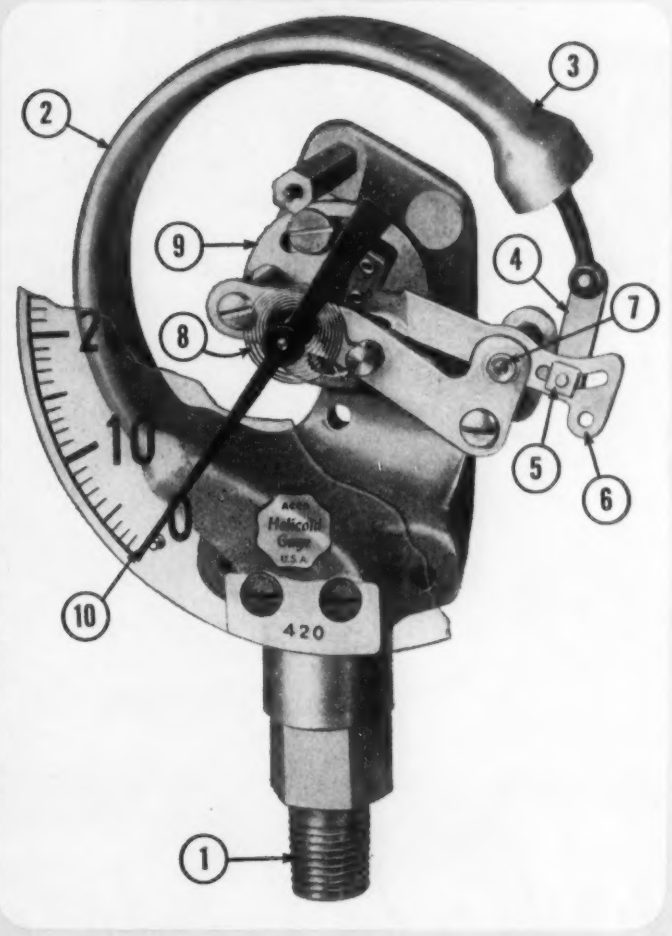
New "Quantometer" is a direct-reading instrument which makes possible the quantitative chemical analysis of as many as eleven elements in alloys, chemicals, etc., in less than one minute. Results appear directly as percentage composition on a series of counters, one for each element being determined. Only one operator is necessary (photograph shows analysis set being tabulated by operator). It is claimed that rapidity with which analysis can be performed "is certain to revolutionize many processes where step-by-step control of composition is necessary." Example cited is metal-producing industry, where many separate melting operations (or holding of melts while composition is being checked) can be eliminated, with great savings in fuel and overhead costs. Production of alloys to much narrower specification-limits than heretofore possible may well usher in a new era of alloys, in which certain types may be produced to provide optimum physical properties by means of exact chemical and physical control. "Quantometer" consists of three units: (1) a source unit producing a high-intensity discharge; (2) a spectrometer employing an original diffraction grating and fitted with twelve receivers—for 12 selected lines—employing multiplier phototubes and highly accurate integrating electrical circuits; (3) a recording console supplying all of the various voltages required to operate the receivers and housing the counting units which provide the final direct analyses.—*Applied Research Laboratories, 4336 San Fernando Road, Glendale, Calif.* and *Harry W. Dietert Co., 9330 Roselawn Ave., Detroit 4, Mich.*



Variable-speed Drive

New "Servotron" variable-speed drive in which speed is controlled electronically is said to embody "a number of new principles and features which can well create new industrial techniques." It operates on a.c. and through an electronic controller runs a d-c. motor at speeds which are infinitely variable

How the Helicoid Gage Works



PRESSURE enters the socket **(1)** connected to pressure source. Pressure to be measured may be air, steam, water, oil, or any liquid or gas. Thru socket, the pressure enters Bourdon tube **(2)**.

BOURDON TUBE **(2)** is an oval-shaped tube of semi-circular form with a sealed end **(3)**. Any pressure in the tube, in excess of external or atmospheric pressure, causes tube to assume a more circular cross section. The flat sides are therefore forced apart, and the tube tends to straighten out at the free end, and tip **(3)** moves outward. The reverse effect occurs under vacuum, when the pressure in the tube is less than the external or atmospheric pressure. This movement of the tube at the free end is called tip travel. In principle, it's just as simple as blowing into a limp glove, causing the fingers to move as they fill with air. As the tube tends to straighten, the tip **(3)** moves outward. On vacuum (pressure below atmospheric) the tip moves inward.

CONNECTING LINK **(4)** connects the tip of Bourdon tube to movement slide nut **(5)**. The tip end of the link travels in a straight line while the movement cam **(6)** travels in an arc around pivot **(7)**.

MOVEMENT SLIDE NUT **(5)** which joins the connecting link **(4)** to the movement cam **(6)** is adjustable, and is used for calibrating gage. Lengthening or shortening distance of slide nut **(5)** from pivot **(7)** is necessary to get exact relationship required to translate the travel at the tip to a 280° revolution of the pointer shaft. Moving the slide nut outward decreases amount of travel of pointer. Moving slide nut inward increases the pointer travel. The Helicoid movement is made with this adjustment at the rear. Hence, the Helicoid Gage can be calibrated as a unit by removing the entire system from the case, but without removing the pointer and the dial. This saves much time when calibrating.

CAM **(6)**, which is toothless, in contact with the Helicoid roller of the movement, multiplies the tip travel into rotary motion of the pointer shaft. A tip travel of 3/16″ is multiplied to a scale length of 10″ on a 4½″ dial. Positive and practically frictionless motion is assured by the rolling action of the polished cam surface on the polished Helicoid roller.

HAIRSPRING **(8)** holds the lower surface of the roller groove in continuous contact with lower surface of the cam facing. Both of these surfaces are polished.

BOTTOM PLATE **(9)** of movement is rotatable. Rotating this movement changes the relationship between the direction of the tip travel and direction of travel of connecting link. This relationship must be such that every increment of movement of the tip is translated into uniform increments of angular rotation of the cam, and hence equal increments of travel of the pointer. The rotary feature of this movement is advantageous when calibrating the gage.

POINTER **(10)** travels uniformly around dial for equal changes in pressure, if the gage is in calibration.

The gage shows the difference between pressure in the gage system and atmospheric pressure, commonly known as gage pressure in contrast to absolute pressure. Zero mark on dial represents atmospheric pressure, about 14.7 p.s.i. absolute at sea level. A vacuum gage shows the difference between atmospheric pressure and that pressure to be measured below atmospheric.

ACCO

(This is page 3, of the new Helicoid Gage catalog. Send for a copy.)

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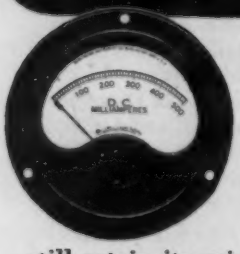

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varnish, lacquer, ceramics, plastics, and other non-conducting coatings which may be deposited on *non*-magnetic base metals such as aluminum, brass, copper, bronze, etc. It measures coating thickness from zero to 0.005" with an accuracy of 3% of full-scale. Measurements may be made on any flat surface, or on convex or concave surfaces having a radius of curvature of not less than 6". Instrument consists of a battery-operated beat-frequency oscillator contained in a 7" × 7" × 7" steel case. Inductance coil of one oscillator is mounted in the end of a tripod-mounted inductor, and is connected to the instrument by means of a shielded rubber covered cable. Earphones enable the operator to determine when the two oscillators are set to the same frequency. Entire instrument weighs approx. 11 lbs. and may be used as a portable field instrument or on a laboratory bench. —*American Instrument Co., Silver Spring, Maryland.*

Wand-type Conductivity Cell

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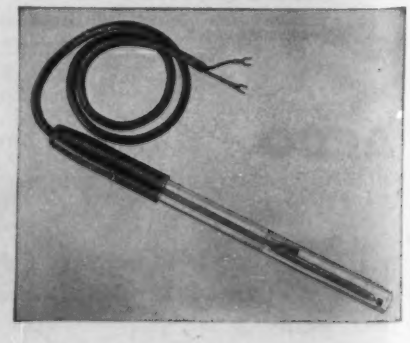

handle. Glass body is approx. 1" O.D. by 20" long. Electrodes are of platinized platinum. Wand is simply plunged into the liquid and conductivity read off in any desired terms from a correspondingly-calibrated conductivity bridge. Operator can stand off at a safe or convenient distance. Cell is provided with heavy rubber-covered leads, and is available in a wide range of cell constants. Although primarily intended as a dip cell, it can be conveniently clamped by suitable means and left in place.—*Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J.*

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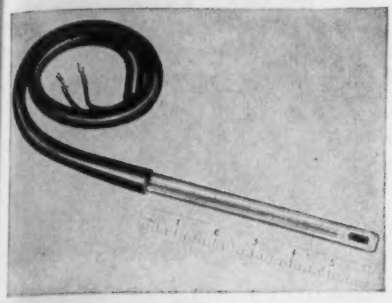
New micro conductivity dip cell makes it possible to check as little as 5 ml. of solution in a test tube. It is made of Pyrex glass, measuring ½" O.D. by 6"



long. A flexible rubber sleeve protects lead wires. This type of cell is convenient in checking solutions in small original containers or sample bottles. A selection of cell constants from 0.1 up permits the checking of any solution ranging from pure distilled water to fuming sulphuric acid, when the cell is used in combination with a suitably calibrated conductivity bridge. For convenience, these new micro cells can be obtained in kits or sets of several selected constants.—*Industrial Instruments, Inc., of 17 Pollock Avenue, Jersey City 5, N. J.*

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New "Model No. 8127" "B" Sweep Calibrator for commercial use in radar and television test work provides calibration marks for use in calibrating

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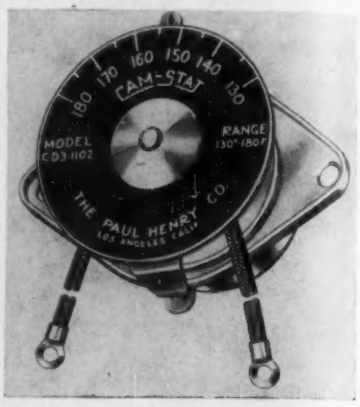
tive, of 66 volts. Gate duration continuously variable from 20 to 3000 microseconds. (All markers that would appear subsequent to this interval are suppressed.) Operating voltage: 110 to 120 volts, 60 cycles. Power consumption: 85 watts. Weight: 23 pounds. Height: 8", length: 16", depth: 7⅞". This unit was designed in collaboration with M.I.T. Radiation Laboratory.—*United Cinephone Co., Torrington, Conn.*

Electric Type Temperature Controller

New "Adjustable Calibrated Cam-Stat Temperature Control" features dial setting with uniformity of dial



accuracy in all units, virtually no increase in space required for mountings over other thermostats without calibrating dial, tamper-proof dial installation preventing changing of adjustable range provided at factory and adaptability to special design requirements. Model shown has an adjustable range applicable to control of water heaters. Adjustable ranges are available between −50°F. and 600°F., with differentials as low as 1°F. "Cam-Stat" may be clamped on tank or element may be immersed in water. Variety of mounting means is available for adapting unit to control of air, gas, liquid or solids. Double-break snap-action contacts have a rating of 12 amperes, 115 volts a.c. or 28 volts d.c., available in s.p.s.t., s.p.d.t. or s.p.d.t.-independent circuit.—*Paul Henry Co., 2037 South La Cienga, Los Angeles 34, Calif.*

Versatile Gage Kit

New "Producto-Chek," designed for production checking, consists of a number of instruments to be used in conjunction with gage blocks for quickly

setting up practically any type of inspection gage. Among instruments are dial indicating snap gage, plain bench comparator, dual bench comparator, angle comparator, square comparator, precision height gage, depth gages, and a series of go-no-go snap gages of any size up to 18". Plug gages and internal gages of any size in steps of 0.0001" can be quickly made up. Also gages such as hole-to-hole, hole-to-base, parallel-bore, pitch diameter, etc. A set of holders from 2" to 18" in length are designed to carry the gage blocks. Bench and surface plate gages can be assembled by using the base block, master flat or numerous other attachments. Beside usual types of gages, there are an indicating snap gage, an indicating internal gage, an angle comparator using two dial indicators (which is set with a sine bar), a multiple bench comparator, an indicating square check gage, etc.; also a set of wires of various diameters lapped to the accuracy of gage blocks. Any of the countless gages can be assembled in five minutes or less. It is said that "the Producto-Chek Gage Kit will actually do the work of more than a million separate gages with gage block accuracy." Kit weighs 40 lbs., is housed in hardwood box 10" × 20" × 4".—*Gage Div., The DoALL Co., 1301 Washington Ave., South, Minneapolis 4, Minn.*

Direct-reading Mach-number Measuring Apparatus

New "Mach Meter" was developed to meet specific need for a relatively small instrument to readily and speedily determine the compressibility factor in

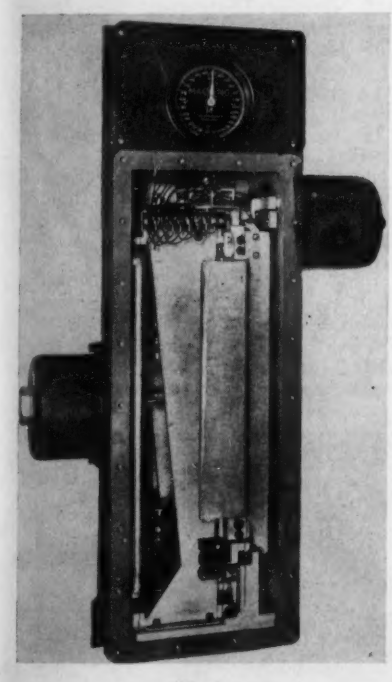
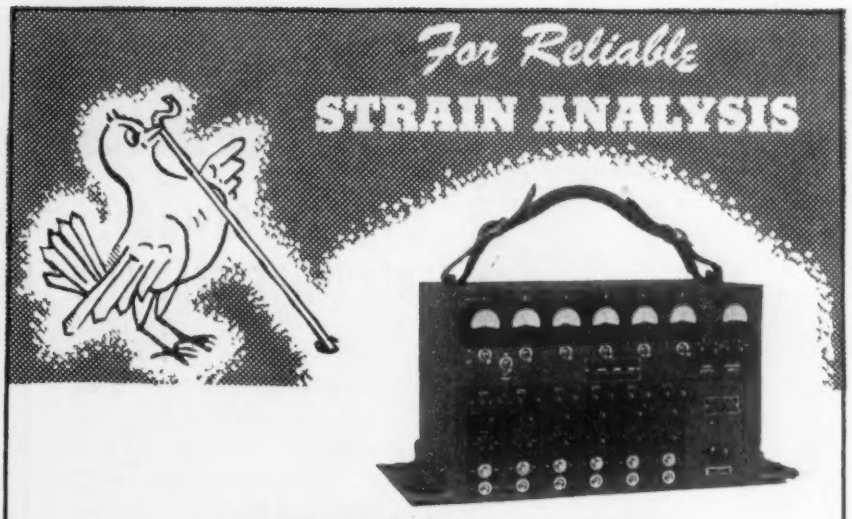


Fig. 1

wind tunnel testing. It utilizes the ratio of static and dynamic pressure in the wind tunnel for obtaining the Mach Number. It is installed in the control room and connections to it are made by airtight tubing from pressure orifices in the large section and test section of the wind tunnel. It is so designed that direct readings may be obtained at a central point and the record may be



HATHAWAY MRC-12 CONTROL UNIT

Compact, extremely portable unit containing all amplifier, power supply equipment and batteries required for 6 channels. Weighs only 25 lbs., measures 14" long x 8" wide x 8¾" high. Accurately detects, amplifies and records all hidden strain, velocity, pressure and vibration. Designed for use with either resistance or electromagnetic strain gages and pick-up units.

Each channel is an individual unit, easily removed for servicing or replacement. Each unit is provided with bridge balancing controls. Strain frequency responses from zero to 500 cycles per second. Contains plenty of stability over long periods of time.

One MRC-12 unit with Type S-12A Oscillograph makes a complete miniature 6 channel strain analysis laboratory. Two MRC-12 units with a Type S-12A Oscillograph make the smallest 12 channel strain analysis laboratory available for static and dynamic strain.

When you buy a Hathaway MRC-12 Strain Gage Control unit it is complete in every detail, you need nothing else, but strain gages.

Write for Bulletin SP-177

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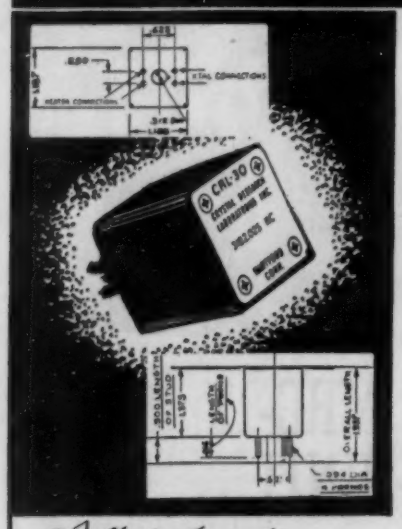

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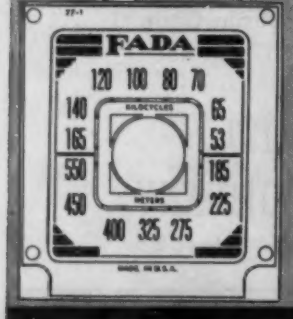

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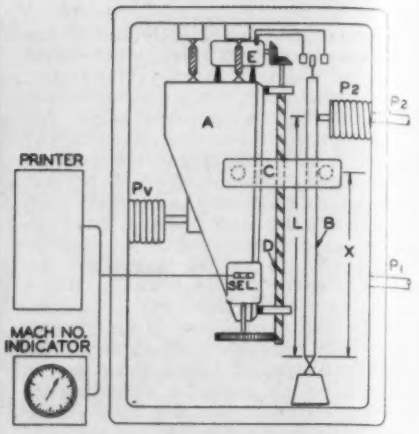
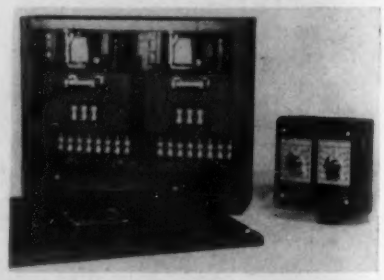


Fig. 2

printed on a permanent chart. Fig. 2 is a schematic diagram showing operation. Tube P_1 is connected to a pressure orifice ahead of the test section while Bellows P_2 is connected to a pressure orifice in the test section. Evacuated bellows P_v exerts a force on bracket A proportional to P_1 and bellows P_2 exerts a force on lever B equal to $P_1 - P_2$. Bracket A and lever B are held together by rider C which is propelled by screw D. Motor E drives screw D thus allowing distance X to vary. Mechanism is totally enclosed in cast Meehanite case 10" wide by 34¼" high by 8⅛" deep. Removable-cover rubber gaskets and rubber-sealed outgoing leads prevent air leakage. Readings ranging from zero to 1.5 are indicated on a dial graduated to 0.005 of a Mach Number. Instrument may be designed for greater range depending upon the requirements. It is said that the invention of this instrument relieves aerodynamic engineers of the necessity of figuring ratios of airplane speeds to speeds of sound at different altitudes (Mach Number) by lengthy mathematical computations. Originally designed for ASTC at Wright Field, it is now available to all wind-tunnel operators.—*Taller & Cooper, Inc., 75 Front St., Brooklyn, N. Y.*

Repeat-cycle Timer

New "Type 2T15U Repeat Cycle Timer," designed for machinery and process control, is recommended for



applications requiring two adjustable timing periods to run in a continuous cycle. Cycle is initiated by either momentary or sustained contacts, and provision for automatic recycling is provided. Each timing period is adjustable from 1/20th second to two minutes. Control is accomplished through snap-action relays said to result in extreme accuracy and interchangeability. Inter-

val variations in repeat cycle timing are said to be less than 2%. New timer is universal for six maximum time ranges from 1.5 seconds to two minutes for each period of the cycle. Each range is represented by a timing element which is snapped into a clip on front of control; timer may be then set for any intervals up to these maxima by dials located either on timer itself or in a small housing at a more convenient location. Illustration shows timer and small dial housing. *Specifications*—Supply: 115 volts a.c. or d.c. Output connections s-p-d-t for normally-open and normally-closed operations. Contacts: 1000 watts 115 to 600 volts a.c. 500 watts 115 to 220 volts d.c.—*Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.*

Street Lighting Control

New "Sun Switch" is designed to control street lighting regardless of fluctuations in weather conditions and the twilight hour. A minimum safety factor

is incorporated in all components, principal of which are standard amplifier tubes, photocell and relay. These factors are coupled with special tungsten alloy contacts on relay (only moving parts). Under ideal conditions of daylight control provides a minimum "lights on" period from 25 minutes after sunset to 25 minutes before sunrise and adjustment is provided to meet customers' specific requirements.—*The Ripley Co., Torrington, Conn.*

Bobbin-type Resistors

New wire-wound bobbin-type resistors rated at 1, 2, and 3 watts at 80°C. ambient are wound with ceramic-insulated resistance wire on molded high-temperature plastic forms and are impregnated for protection against tropical humidity conditions. Resistance tolerance is available from ±½% to ±5%. Standard temperature coefficient wound with nickel-chromium wire is 0.017%. Lower coefficients can be provided by use of special alloy wires. Maximum permissible temperature, am-

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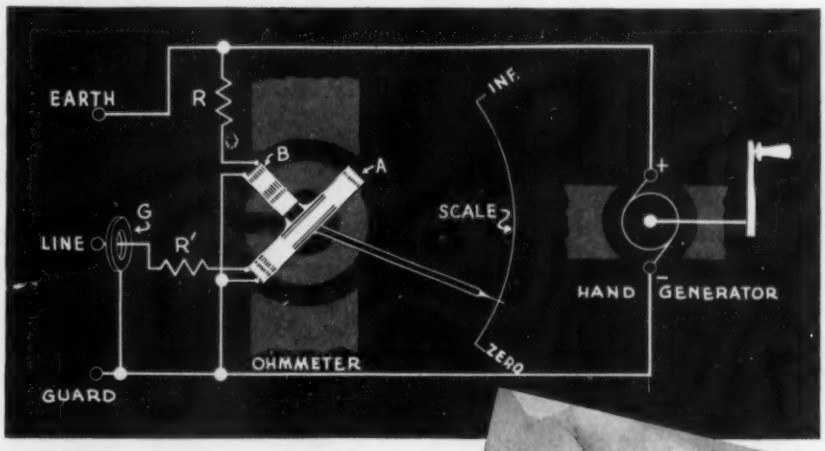

In what we term a cross-coil true ohmmeter, two coils are mounted in fixed relation to each other on the same pivot-and-jewel moving system in the field of a permanent magnet. "Current" flows in coil A and "potential" in coil B, and they are connected so that their respective torques oppose each other. Since there are no control springs, the opposing coils give a true ratio of E/I, and ohms (or megohms) are indicated by a pointer over a scale. The readings are independent of the voltage of the hand-driven d-c generator, because any change in the voltage affects both coils in the same proportion.

The "Megger" instrument is simplicity itself. The circuit diagram shows *all* elements—hand-cranked generator, fixed resistance coils and ohmmeter with pointer and scale. Nothing more is needed and nothing could be simpler. In making resistance tests, you merely connect leads from the instrument to the apparatus or circuit under test, turn the crank for a few seconds, and read the insulation resistance directly on the scale.

Power generation and distribution practice has dictated certain standards of quality and performance that every piece of electrical equipment is expected to meet. "Megger" insulation testing instruments have been and will continue to be built in conformity with these high standards.

For complete descriptions and applications of all types of "Megger" Insulation Testers write for Catalog 1685-I.

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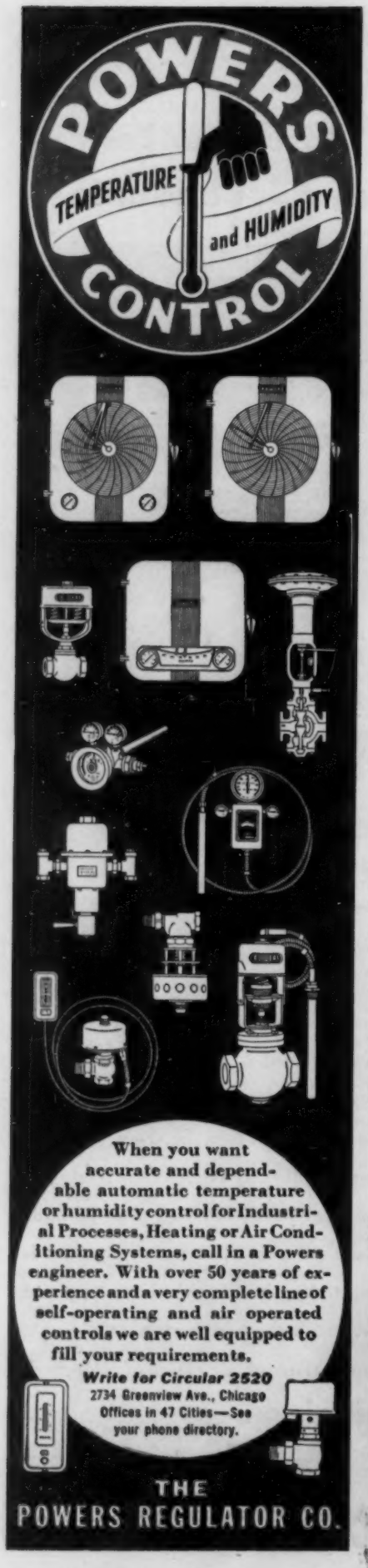
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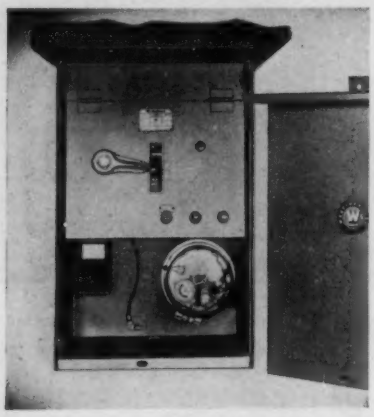
bient plus rise, is 150°C. "Type RX3," 9/16" diam. × 15/32" long carries maximum resistance value of 100,000 ohms when wound with 1.5-mil ceramic-insulated wire or 25,000 ohms with 2.5-mil wire. "Type RX4," ¾" diam. × ¾" long, has maximum 300,000 ohms with 1.5-mil wire and 75,000 ohms with 2.5-mil wire. "Type RX5," ¾" diam. × 1" long carries 500,000 ohms with 1.5-mil wire, or a maximum of 125,000 ohms with 2.5-mil wire.—*Sprague Electric Co., North Adams, Mass.*

Oil Field Pumping Control

New a-c. magnetic oil field pumping control combines circuit protection and motor control in a single unit to save space and wiring. Is especially designed



to provide for automatic starting and stopping of oil field pumping motors. Weather-proof enclosure (partly shown in illustration) permits outdoor pole mounting close to load. Dead front inner door protects operator from live parts when cabinet door is opened. New starters are available in two basic types, each providing overload and low voltage protection. Automatic unit includes AB breaker, "De-ion" linestarter, lightning arrester, hand-reset low voltage relay, "Hand-Off-Automatic" selector switch to permit manual operation, socket and time switch. Time switch automatically controls specific pumping periods during the day. Local control unit includes AB breaker, "De-ion" linestarter, lightning arrester, and Start-Stop pushbutton. Ratings are from 1 to 25 hp, 110, 220, 440-600 volts. —*Westinghouse Electric Corporation, Box 868, Pittsburgh, Penna.*

Airplane Instrument System

New team-like electrical system of instruments, known as "compass-controlled directional gyroscope," will give an airplane sustained and "pinpoint"

directional accuracy, except for wind drift deviations, in flights controlled by autopilots, without necessity of gyroscope corrections by pilots or navigators. In this new system, the compass and gyroscope are harnessed into a steady computing unit through an electrical coupling, so that errors which normally would crop out in either of those instruments operating separately are corrected automatically. Moreover, instruments and electrical and magnetic transmitters are so connected that if gyro was knocked out of operation, pilot can flick a switch and get directional data directly from the compass. Also, should compass be shot out, gyroscope will continue its normal functioning. Compasses are remotely located, usually far out on the wings of the plane, hence are not disturbed by units in cockpit. They are connected with an electrical transmitter. Electrical impulses from compass transmitter go to new type of small and light electric-driven G-E gyroscope. Previously, it is said, these compass impulses went directly to instrument dials in cockpit or other places in the plane without any connection with the directional gyroscope. In new system, gyroscope also contains advanced elements, is said to be the first instrument of its kind to have universal freedom of motion, smooth and accurate operation not thrown out of kilter by sharp dives, spins, rolls, etc. Prior to its development, it is said, directional gyroscopes frequently would go haywire, or tumble, when the plane went into a bank or spin of more than 60° off line, unless it had been set by control devices before the maneuver. That meant that the pilot, after righting the plane, would have to cage and reset the gyro. New gyro, around which this instrument system is built, weighs less than the one which it will replace; and has some additional autopilot elements not contained in the old type.—*Apparatus Department, General Electric Co., Schenectady, N. Y.*

Pressure Switch

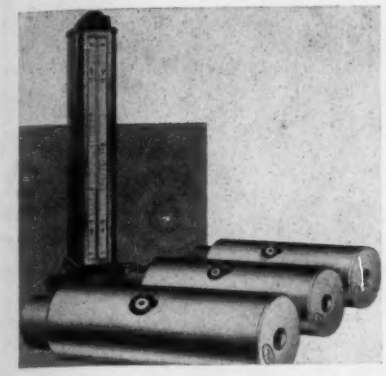
New model of "Pressure-Clix" embodies a sealed-in snap action switch approved by Underwriters Laboratories for electrical loads up to 6 amperes

at 64 volts d.c. and 10 amperes at 110 volts a.c. Pressure adjustment can be locked and sealed against tampering. Direct wire connections are made through grommeted opening in steel cover to insulated terminals, thereby eliminating spliced wires. Diaphragm is of Fairprene, backed by a mushroom-shaped plate of restricted travel to pre-

vent stressing of diaphragm. Large area of diaphragm and switch action assure close differentials. Full ⅛" inlet prevents clogging and husky mounting bracket can be adjusted to meet individual requirements of cable connection. Snap action switch can be changed to normally-off or normally-on by moving one wire. All parts are rustproof. Pressure ranges up to 150 lbs./in.^{2}.—*The Nason Company, 7663 Epworth Boulevard, Detroit 4, Mich.*

Heads for Air-gage System

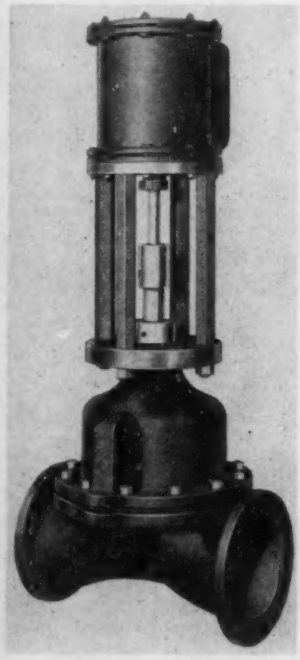
New class of gaging heads, identified as "Class B," for use with "Federal-Metricator" air gaging system, range from 0.240" to 2.510" diameter. Their

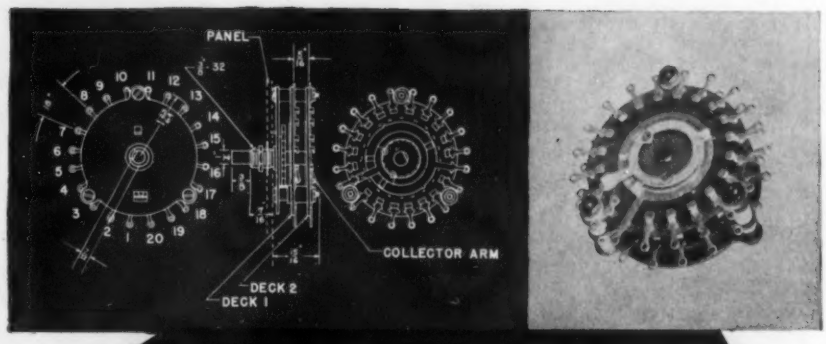


principal difference is that they are not chrome-plated and lapped: they are hardened steel, fine-ground. Having the same measuring accuracy as the higher-priced gaging heads, they should appeal to shops having short production runs or frequent change-overs where the higher priced gaging heads would prove too costly for the requirements.—*Federal Products Corp., 1144 Eddy St., Providence, R. I.*

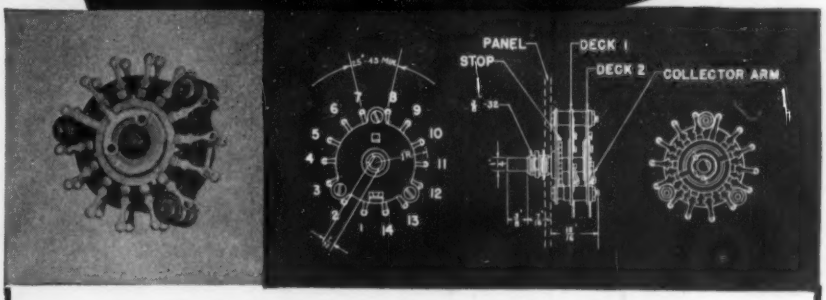
Air-operated Valves

New "Air-actuated Piston Operators" are announced for remote control of "Hills - McCanna (Saunders Patent)





IN LAST PLACE
ON THE TROUBLESHOOTER'S CHECK LIST
AND PROUD OF IT!



J-B-T Instrument Type Rotary Selector Switches are available in 20 position SS-20 and 14 position, SS-14 models, one to six decks, non-shorting standard, and shorting on special order.

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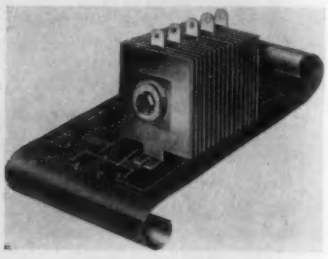
Diaphragm Valves." The Saunders type valve has long been accepted in chemical and allied fields because of its packless but leak-proof construction, complete isolation of bonnet assembly, freedom from clogging, and other advantages. Makers of this valve have arranged with Westinghouse Air Brake Co. for supplying properly-designed remote-control systems of various types and capacities, all designed for actuation of Saunders type valves. Illustration shows one type of piston operator on a Saunders valve but does not show "Wabco" remote pilot valve, etc. Available valve sizes, 4" to 12".—*Hills-McCanna Co., 2341 W. Nelson St., Chicago, Ill.*

Self-cooling Disk Rectifier

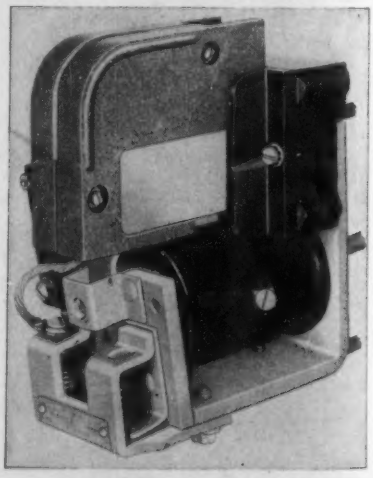
New copper sulphide dry disk rectifier does not require forced cooling, is rated 50 amperes for 6-volt battery taper charging. Two rectifiers may be



operated in parallel from separate transformer secondaries to provide 100-amp. max. charging rate without a fan. Battery chargers of this type operate from the usual 110-volt a-c. power supply. New rectifier makes possible, for the first time, the design of 50-amp. chargers without any moving parts.—*Benwood-Linze Co.*

Magnetic Contactors

New "Type M-210-H" single-pole magnetic contactor is announced for machine tool control, marine and mine



application, and similar severe-duty applications where space is limited. Small compact design saves panel space; unit construction speeds assembly and assure accurate alignment of all parts. Rear or front-connected units are available. Contactor is entirely assembled on a formed frame which also serves as a path for the

magnetic flux. Small-frame contactors in this line are limited to applications in which coil voltage and voltage of circuit being interrupted do not exceed 250 volts. Deep frame contactors, which provide greater winding space for the operating coil, are suitable for voltage up to 600 volts. Operating coils are rated for continuous duty and will operate the contactors at 80% to 110% of their rated voltage. Contacts are insulated for a maximum potential difference of 600 volts among parts.—*Westinghouse Electric Corp., Box 868, Pittsburgh 30, Penna.*

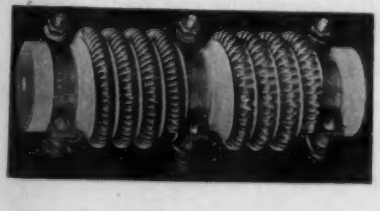
Airplane Approach Angle Indicator

New approach angle indicator for airport landing uses a 100-watt incandescent bulb to project a tri-color beam over a one-mile range indicating the

correct angle of approach. It sends the light through seven lenses, breaking it up into green, red and amber beams. Green beam indicates correct angle of approach; red (lowest) warns pilot that he is too low; yellow (upper) warns pilot that he is too high. To avoid possibility of glare and confusion with other lights, beams flash on for one second and off for one-half second, a motor-driven shutter providing sharp cut-off. In clear weather, new approach angle indicator is dimmed; in low visibility, 100-watt bulb suffices to impart an unmistakable signal to pilot under any conditions where contact lights are of use. For larger airports, a 240-watt lamp is available, giving about three miles range at night.—*Westinghouse Electric Corp., P. O. 868, Pittsburgh 30, Pa.*

Center-tap Resistor

New "Type CAM" center-tap resistor consists of a steatite core, upon which is wound a helical resistance wire element. Center and end taps are half-



To test over-all performance

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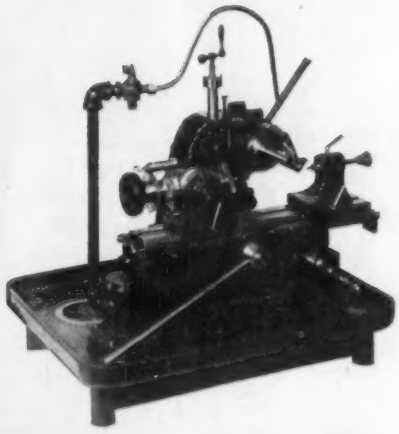

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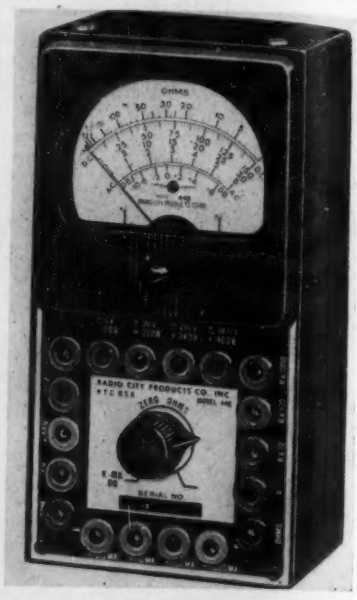
straps securely clamped to core, assuring mechanical rigidity independent of support by resistance element: fine wire can be tapped off with assurance of a good non-heating connection. Tap assembly employs brass nuts and bolts and stainless steel lock washers. All parts are zinc-plated, plus an additional chromate dip plating.—*Techtmann Industries, Inc., 828 North Broadway, Milwaukee 2, Wisconsin.*

Pocket Multitester

New "Model 448 Pocket Multitester" is said to feature "six testing instruments of high accuracy in one compact metal case." Indicator is a 3" square



instrument with a 200-microampere movement and a sensitivity of 5000 ohms per volt. Ranges are: D-c. volts, 0-5-50-250-1000, first scale division 0.1 volt; A-c. volts, 0-5-50-250-1000, first scale division 0.1 volt; Output volts, 0-5-50-250-1000, first scale division 0.1 volt; D-c. ma., 0.5-10-100-1000, first scale division 0.01 ma.; Ohmmeter 0/1000 0/10,000 0/.1 meg 0/1 meg; Decibel meter −6 to + 10, −14 to + 26, −28 to + 40, −40 to + 52 db. Db range is calibrated for a line of 500-ohm impedance. For lines of other impedance, correction charts are supplied. Dimensions are 5⅞" × 3 1/16" × 2⅛" Weight 1¾ lbs., complete with self-contained batteries, ready to operate in snap spring contact holders. — *Radio City Products Co., 127 West 26th St., New York City.*

Oxyacetylene Cutting Machine Control

New "Electronic Bloodhound" is a photoelectric pick-up type tracing device for pantograph type oxyacetylene cutting machines. Announcement states that it "radically simplifies steel cutting operations and for the first time makes intricate design cutting practical—considerably expanding the present application of torch cutting machines in industry." Illustration shows equipment installed on "Oxygraph" cutting machine. It may be installed in place of the manual or magnetic tracing device or any pantograph type machine.

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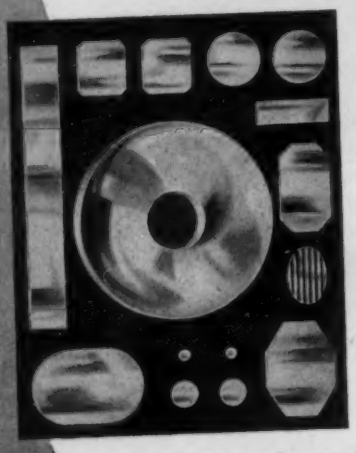

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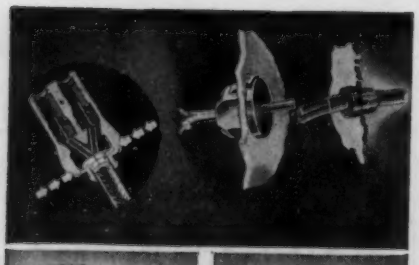

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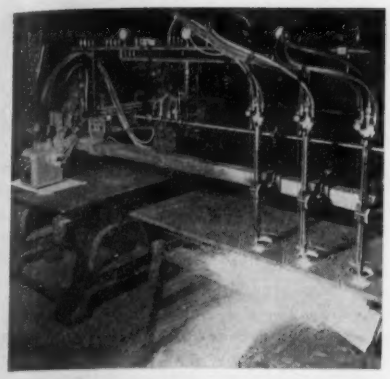
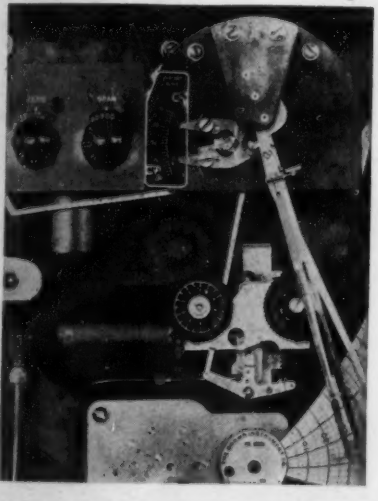


No alterations are necessary. Templates required for automatically-controlled cutting are simple outline drawings or silhouettes—a black outline about ⅛" wide against a white background, or any other color combination which provides sufficient light contrast. These drawings may be treated with a protective coating for long life. Equipment consists of two units: tracing head and control box. All working parts are fully protected and electron tubes designed for long life. Equipment is easily attached to any "Oxygraph" or "Travograph" cutting machine in place of conventional equipment. — *Air Reduction, 60 East 42nd St., New York 17, N. Y.*

Additional Adjustment for Automatic Controllers

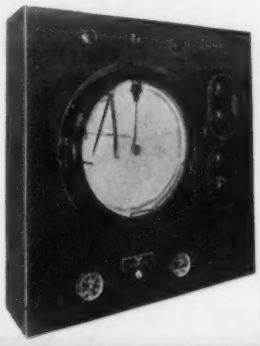
New "Adjustable Indexet," for maker's air-operated automatic controllers is described as essentially a pneumatic



receiver with two new mechanisms added, consisting of "span" and "zero" shift. Span or proportional adjustment permits a change between span through which instrument control point is moved and change in transmission pressure which moves control point. Span dial is calibrated in terms of distance in percent of full-scale that setting-arm will move along chart per full-scale changes in pressure. (Span is the multiplying and dividing adjustment.) Zero, or linear, adjustment adds or subtracts a constant value. Zero dial is calibrated in terms of full-scale and moves zero position along chart. New "Adjustable Indexet" features: (1) Span adjustment, 0 to 200%; (2) Zero

"CYCLELOG"

A Bodine Type K motor provides power for the Foxboro CycleLog Controller, which controls the rate of temperature change in many manufacturing operations.



The Bodine Type K motor, made either with or without speed reducer, provides the operating power for many precision control mechanisms like that of the "CycleLog." One of the smallest distributed wound motors manufactured, it is widely used in applications of this type because of it's small size and extreme reliability. It is available in ratings of 1/750 to 1/2000 horsepower, synchronous or nonsynchronous with or without speed reducer.

Bodine has made high quality motors for precision application for over 40 years. Their engineers will be glad to recommend the correct motor for your application. Bodine Electric Co., 2244 W. Ohio St., Chicago 12, Illinois.

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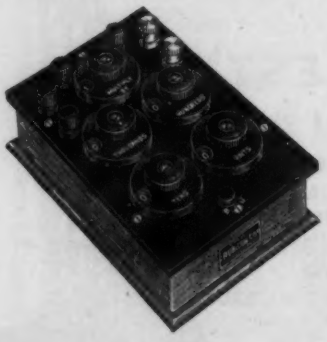

Rubicon Wheatstone and Kelvin Bridges are available in a number of types to suit various applications. All are made in accordance with the highest traditions of the instrument maker's art and are fully guaranteed.

Described in Bulletin 100 which also lists Rubicon Resistance Boxes and Shunts as well as NBS and Reichsanstalt Resistance Standards.

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shift adjustment, −100 to + 100; (3) Readily accessible adjustments without chart disturbances; (4) Control point is undisturbed when making adjustments; (5) Direct action; (6) Limit stops prevent setting-arm from exceeding any desired limits.—*Brown Instrument Co., 4482 Wayne Ave., Philadelphia 44, Penna.*

Jar for Tumbling Tests

New Tumble Jar unit, for laboratory tests of textiles, paper, foods, chemicals, colors, etc., comprises a chemical stoneware cylindrical jar, 6″ diameter by 8″

high with reinforced rim, rubber gasket, ceramic cover, metal cover clamp for leak-proof closure, and mounted on a sheet metal base with crank to permit rotation by hand. It is suitable for tumbling solids, powder, or dissimilar liquids—and for mixing, blending, dispersions, emulsions, colloids, solutions. Unit is safe for handling inflammable solvents or materials. Overall dimensions 13½″ × 13½″ × 15″ high. Motorized units are also available.—*Andrew Technical Service, 111 East Delaware Place, Chicago 11, Illinois.*

Portable Wheatstone Bridge

New portable Wheatstone bridge is arranged for making resistance, Murray, Varley, Hilborn, 3-wire Varley and Fisher Loop Tests, in laboratory, pro-

duction or communication measurements. It is easily portable and rapid in operation. Case dimensions, 8⅞″ × 7⅜″ × 5¾″; weight, 8 lbs. Accuracy 0.1% ±0.01 ohm from 1 to 40,000 ohms. All contacts are enclosed. Limit of error for the ratio resistors is 0.05%. Ratios of 1/1000, 1/100, 1/10, 1/9, 1/4, 1/1, 10/1 and 100/1 are clearly marked for rapid selection. Additional ratios of

M/1000, M/100 and M/10 are provided for looping line faults. A cam switch with three positions sets bridge for the various loop tests. Galvanometer is a replaceable unit provided with a clamp lock. Coil resistance is 250 ohms. Sensitivity is 1 microamp. per scale division deflection. Three push buttons select a like number of sensitivity ranges (0.01, 0.1 and 1.0) to protect galvanometer. Switches are wired to protect galvanometer against switching surges. Resistances in excess of 100,000 ohms can be measured with high accuracy by using an external battery. Resistance measurements under one ohm can be measured accurately provided precautions are taken to eliminate lead resistance and external contact resistance. This bridge is available at lower cost without the looping features. It can also be supplied uncased for inclusion in complete equipment panels and bays.—*The Winslow Company, 9 Liberty St., Newark 5, N. J.*

Noise and Field-intensity Meter

New "Model NMA-4" noise & field intensity meter provides single-band frequency range 100-400 megacycles. Applications include locating and indi-

cating in microvolts, the amplitude of radio noise causing disturbance to reception, determining effectiveness of filtering and shielding electrical apparatus which produces radio noise at ultra-high frequencies, indicating and recording in microvolts per meter the field intensity of radio and television transmitters. Instrument's radiofrequency, amplifier, mixer and oscillator circuits use "butterflies" which vary capacitance and inductance simultaneously. Noiseless tuning results from absence of sliding contacts. Circuits maintain a high degree of stability and nearly constant value of resonant impedance which provides for substantially uniform calibration. Stability of calibration is determined by "shot noise" developed in the plate circuit of the rf. amplifier. Voltage range 1 to 100,000 microvolts. Field intensity range 5 to 100,000 microvolts per meter. Performance and construction specifications are in accordance with acceptable government requirements. Designed for portable or laboratory use. Operation 105-125-volt a.c. Size 15 3/16" high, 21½" wide, 14 9/16" deep. Weight 56 lbs. Acces-

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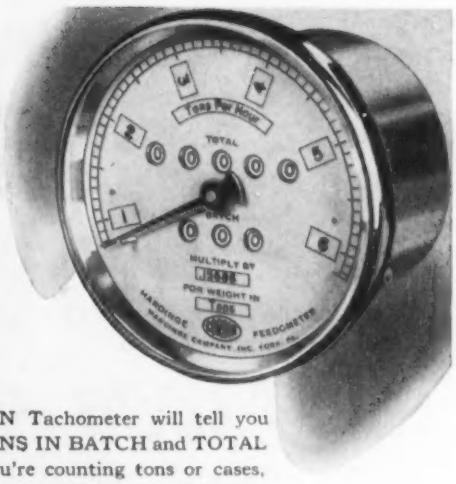

At a glance, the face of this CORBIN Tachometer will tell you the number of TONS PER HOUR, TONS IN BATCH and TOTAL TONS up to that time. Whether you're counting tons or cases, bottles, bales . . . or measuring in lengths, or counting revolutions . . . Corbin can engineer a Corbin Tachometer to meet your requirements.

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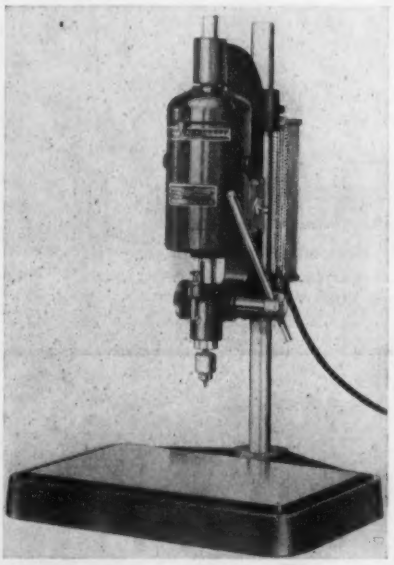

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Unique construction enables operator to rapidly determine temperature even on minute spots, fast moving objects, or smallest stream; no correction charts, no accessories, no maintenance expense. Special "FOUNDRY TYPE" and "Universal TRIPLE RANGE" have, in addition to standard calibrated range, a red correction scale determining TRUE SPOUT and POURING TEMPERATURES of molten iron and steel when measured in the open.

Stock ranges 1400° F. to 5000° F.

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MAYBE our imagination is flying a **little** high. But to get out of the sky and down to earth, it's a fact that the "Red-Reading-Mercury" column on a Palmer Thermometer makes it possible to read temperatures more clearly, easily, at a far greater distance—even through smoke and steam!

This clear, sharp "readability" . . . plus precision manufacture and longer life . . . make Palmer Thermometers the choice of engineers the world over.

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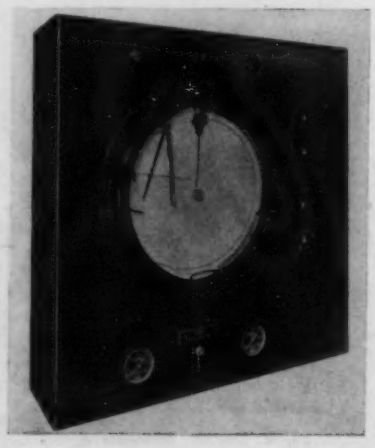
sories provided for inductive, conducted and radiated energy measurements.—*Stoddart Aircraft Radio Co., 6644 Santa Monica Boulevard, Hollywood 38, Calif.*

Temperature Rate-of-rise Controller

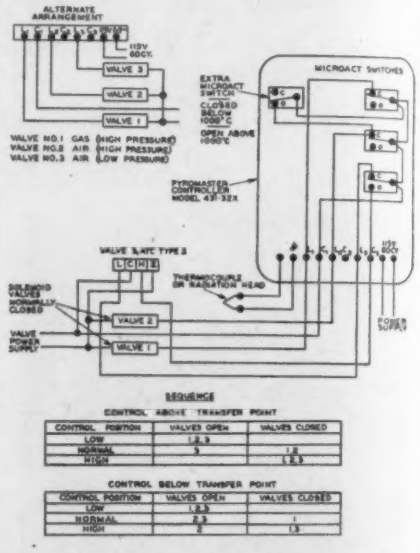
New "CycleLog Controller" has been developed for batch-type processes and other operations where rate of temperature increase or decrease must be controlled, as well as actual processing temperature and duration. Name "CycleLog" was adopted as expressing instrument's function in controlling and recording all the steps of a complete process cycle. No time-cams or supplementary instruments are employed.



"CycleLog" control is completely automatic, according to whatever schedule is predetermined by adjustments of four setting knobs on instrument panel (see illustration). In batch dyeing, for example, "CycleLog" controller will bring bath temperature up from any starting point to the desired holding point, at any desired rate of rise from 1°F. to 8°F. per minute. It will then hold bath at correct temperature for correct period of time, and then shut off heat supply and signal operator that the cycle has been completed. By reference to instrument chart and its notations, any cycle can be exactly duplicated as desired, in any similar plant and regardless of season.—*The Foxboro Co., Foxboro, Mass.*

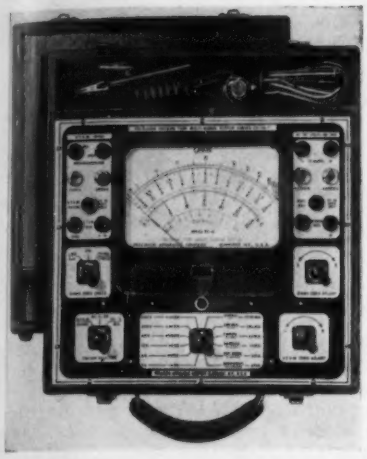
Two-stage Heating Controller

New adaptation of "Pyromaster Microact Controller" (see *Instruments*, Sept. 1945, page 644) to special requirement of two-stage firing of gas furnaces is announced. Drawing shows installation for one type of controller. A "Model 431-30" with an extra switch is used and the temperature at which the transfer from low-temperature firing to high-temperature firing is set by adjusting the extra switch. — *The Bristol Company, Waterbury 91, Conn.*



Multi-range Vacuum-tube Tester

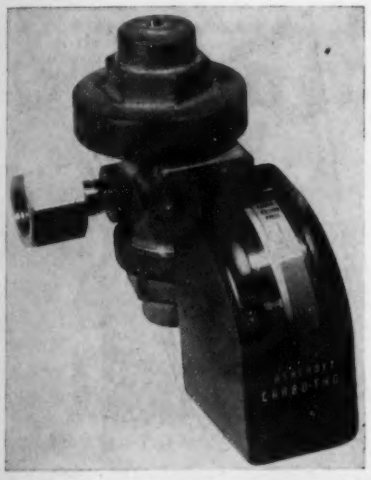
New "EV-10-P" portable multi-range vacuum-tube tester has all zero-center vacuum-tube voltmeter ranges, also direct-reading megohmmeter, milliammeter, ammeter, output and decibel meter plus standard-sensitivity 1000-ohms-per-volt a-c. and d-c. voltmeter ranges. Incorporating a 7" size indicator, it plys a stabilized bridge circuit using only 3 tubes, a 6C5, 6X5 and VR-150. Power supply plate voltage output remains constant over severe line voltage variations. Indicator is zero-center on all ranges when used in the VTVM circuit. A single master range selector provides rapid positive shift from one range to another. A vacuum-tube probe for supersonic, r-f. and u-h-f. voltages, known as "Series RF-10" probe, is available as an optional accessory. It incorporates a peak rectifier circuit around a 9002 miniature tube. Instrument is furnished in a hardwood case



with removable cover and tool compartment, complete with tubes, ohmmeter battery and testing probes. Overall dimensions are approx. 12" × 13" × 6".—*Precision Apparatus Co., 92-97 Horace Harding Blvd., Elmhurst, L. I., N. Y.*

CO_2 Indicator-controller for Beverage-vending Machines

New "Ashcroft Carbo-Trol" combines a two-stage regulator, pressure switch, and dual edgewise pressure gage into



one unit for coin-operated beverage vending machines. Its function is to take carbon dioxide from cylinder at high pressure and supply it to beverage-dispensing machine at low regulated pressure. It provides simultaneous indication of cylinder gas and regulated gas pressure and, when cylinder is emptied and regulated pressure drops below set value, it actuates low cut-out pressure switch, cutting off current from vending machine until CO_2 cylinder is replaced, thus preventing below-quality drinks.—*Manning, Maxwell & Moore, Inc., Bridgeport 2, Conn.*

Photographic Viewer

New "Kimac Master" accommodates all films from 8-mm. movie film up to film 2½" wide, including 2" × 2" slides and mounts. This is a table model, usable with either a.c. or d.c. Base is of die-cast aluminum. An ordinary 15-watt lamp and opal glass screen provide even illumination. Two optically ground and polished lenses in a focusing mount permit two-eye vision in ordinary light.

No projection screen or darkened room is necessary, making outfit ideal for small group showings as in visual education, magnified examination of 70-mm. and 35-mm. x-ray film, etc.—*Kimac Co., Old Greenwich, Conn.*

Pocket Compass

New "Model 35" compass is made entirely of plastics except for its magnets, bearing and pivot, measures 2½" by ⅝". Special non-freezing damping liquid stops card within three seconds. An adaptation of maker's compass which was standard equipment on armored vehicles, it has a floating card with 5° divisions. New compass "is unbreakable: experimental compasses

GAERTNER

MICROMETER SLIDES

with

MICROSCOPE or TELESCOPE

for precision linear measurements up to 4" reading to .00005"

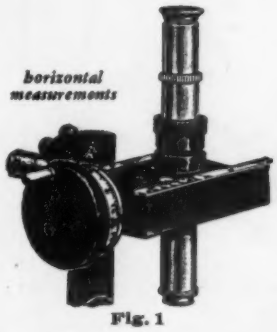


Fig. 1

Dependability and precision are insured by extremely accurate screws and fine craftsmanship.

When used with the various types of support bases available they can be used as small comparators for horizontal linear measurements (Fig. 1).

The microscope mounted parallel to the slide permits depth measurements and micrometer focusing (Fig. 2).

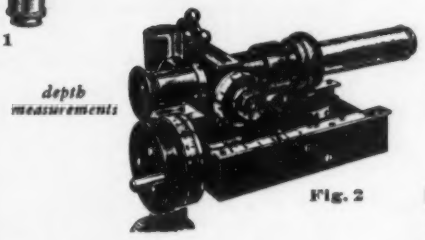


Fig. 2

Vertical orientation permits use as a small cathetometer for vertical linear measurements (Fig. 3). Interchangeabiliy of microscope objectives and eyepieces permits a wide selection of magnifications.

These instruments are ideal for the variety of applications required in testing and inspection departments, laboratories and shops.

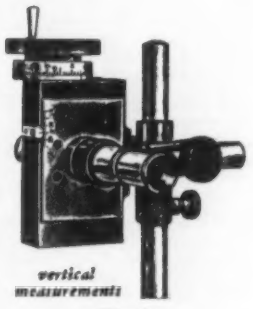


Fig. 3

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Drillet Box Jig Saves Up to 75% of Jig Body Expense and Labor!

The six-sided Drillet Box Jig above and at right has a range of 125 different sizes, making it possible to accommodate all sizes up to 6" capacity—for drilling, reaming, counter boring, counter sinking, spot facing, tapping, etc.

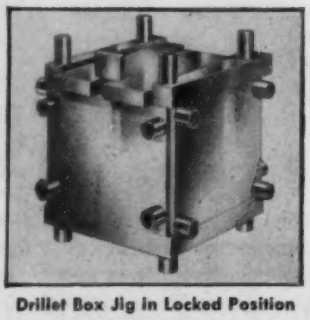
The Drillet Box Jig makes special tool design for drill jig unnecessary. Saves up to 75% of the time and cost of building a jig body. By merely turning thumbscrews and raising leaf, parts may be quickly loaded or unloaded. The jig may be used on all six sides, taking advantage of its full capacity.

Another useful product is chewing gum. You can enjoy chewing Wrigley's Spearmint Gum even while your hands are busy. The pleasant chewing helps to steady you—helps keep you alert and on your toes when you're doing a monotonous job.

Besides the satisfaction chewing gives you, it helps keep your mouth moist and fresh so you naturally feel better—and feeling better you work better.

Scores of industrial plants report that they have stepped up their workers' morale and efficiency by making chewing gum available to them.

You can get complete information from The Chicago Drillet Corporation, 920 S. Michigan Ave., Chicago 5, Ill.



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AA-59

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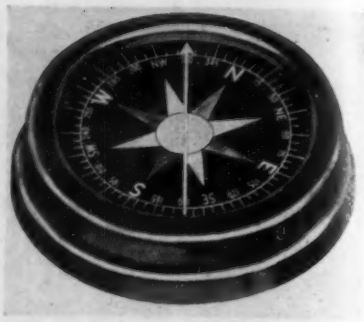


were run over by trucks and even tanks, without damage." It is exceptionally well balanced, employing two magnets instead of one. All parts are machined to close tolerances.—*Sherrill Instrument Co., Peru, Indiana.*

Fixed- or Adjustable-rate Interrupter Timer

New Self-Timing Interrupter unit comprises a glass-enclosed hot-wire type thermal element, a small power relay and a resistor (when required) to properly apportion flow of current between thermal element and relay coil. It can be supplied with a fixed predetermined rate of interruption or with an external variable adjustment. Fixed unit can be supplied in either frame construction or in plug-in metal enclosures; adjustable unit is available in plug-in enclosures only. Timing range: 1-12 pulses per second; voltage: to 32 volts d.c. and 125-volt 60-cycle a.c.; many contact arrangements available; contact rating: 10 amps (non-inductive load at sea level). Applications include industrial controls, life testing circuits, process timing, aging equipment control, etc.—*Electronic Controls, Inc., 44 Summer Ave., Newark 4, New Jersey.*

"Cold Light" Lamp

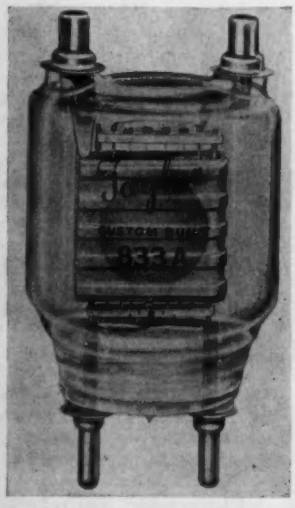
New "cold light" lamp is said to convert electric power directly to light and by-pass the factor of heat. With efficiency several hundred percent greater than lamps of the incandescent type, industrial and commercial uses are

said to be limitless. Light is produced by the direct ionization of inert gas when a concentrated electron stream is directed through a closely-wound spiral having an open end. Lamp life is extended by having entire bulb filled with inert gas so that it functions as "a virtually inexhaustible reservoir." Moreover, light intensity from a given voltage is far higher than that possible with any other light source. When

used as a photoflash lamp capable of many thousand flashes, it produces a light "one hundred times brighter than the sun" by a flash of 0.0001-second duration. High lamp efficiency enables two or three small flashlight cells to be used as the power source with auxiliary equipment. Among already-available types is one which produces light in all colors of the spectrum for color photography. — *Amglo Corp., 4234 N. Lincoln Ave., Chicago, Ill.*

High-power Triode

New improved 833A transmitting triode is similar to conventional 833A, but contains a zirconium-coated anode with zirconium sprayed only on part of plate



most subject to heat during operation. Electrical characteristics: Filament (thoriated tungsten) 10 v. (a.c. or d.c.) at 10 amps. Amplification factor: 10. Inter-electrode capacitances: G-F 12.3 mmf.; G-P 6.3 mmf.; P-F 8.5 mmf. Driving power, 35 watts; power output,

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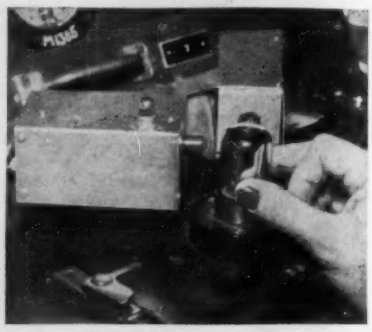
1600 watts; highest frequency for maximum ratings, 20 Mc.—*Taylor Tubes, Inc., 2312 Wabansia Avenue, Chicago, Illinois.*

Heating-system Calculator

New "Heat-O-meter" is a calculating device for measuring radiation for steam and hot water heating systems. It is a round dial with three concentric celluloid printed disks, containing sizes of mains, returns, risers, radiator sizes and capacities, round and sectional boiler net ratings, chimney flue sizes and capacities with minimum and maximum heights, hot water tank sizes and capacities, fuel oil tank sizes and capacities, hot water generator capacities and other information enabling users to have correct answers "at their finger tips." — *Heat-O-meter, 424 West 42nd St., New York 18, N. Y.*

Tube-testing Tappers

New solenoid-operated tube tappers provide uniform (and adjustable) control of force, angle and timing of blows on electron tube envelopes to detect



shorts, r-f. and audio noises, and other faults due to tube structure; were specially designed to eliminate variations resulting from use of hand mallets.—*Sylvania Electric Products Inc., Emporium, Penna.*

Rectifier Tube

New 4B32 rectifier is said to meet need for a rectifier having low voltage drop, high current capacity and ability to function in exposed locations without auxiliary heaters and controls. It is xenon filled and performs perfectly in ambient temperature from —75°C. to +90°C. Mechanical construction is especially rugged. Ratings: peak inverse voltage, 10,000 volts; average anode current, 1.25 amps.; voltage drop, 10 volts; ambient temp. range, —75°C. to +90°C; filament voltage, 5.0 V.a.c.; filament current, 7.5 amps. —*Chatham Electronics, 475 Washington Street, Newark 2, New Jersey.*

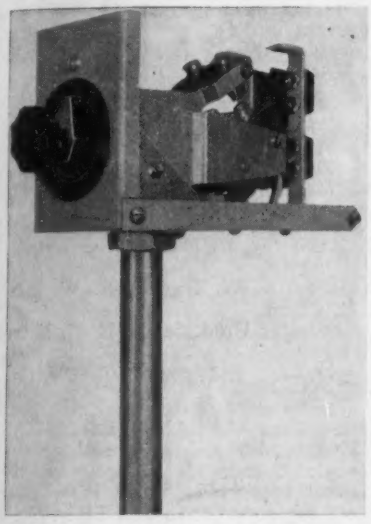
Electronic Switch

New "Model 8336" electronic switch embodies all features of maker's switch operating with 30 amperes, but can also be used in the presence of explosive gases. This was not possible with the older type of switch owing to open

contacts; new model uses a relay with contacts which are hermetically sealed. New switches are intended primarily for pressureless limit switching, floatless control of liquid levels and to eliminate contact arcs and welds. Maintenance beyond replacing the Type 2050 Thyratron tube at infrequent intervals is not required.—*United Cinephone Corp., Torrington, Conn.*

Temperature Controllers

New "Model E Temperature Limit Switch" is available as a "one-switch," "two-switch" or "three-switch" model



("Model E 1 - E 2 - E 3"). Among its unusual features is the fact that it has but one light-weight moving part. As a "three-switch" model, "Model E" is recommended for use (a) where the load is divided into three parts, (b) where one switch is used for controlling, one as a high limit, one as a low limit, (c) to give definite steps or positions to a three- or four-position diaphragm motor, (d) to give three-speed control of variable-speed motor. Other features: Corrosion- and heat-resisting tube. Dial pointer for easy setting. Locking screw locks temperature setting. Increased adjustable range up to 700°-1000° (in some cases up to 1200°). Each switch has a separate adjusting screw so that the differential between the two switches on the "E-2" and the three switches on the "E-3" can be set at any desired point. Maximum differential between switches is approximately 150° for the two switches of the "E-2" or any two switches of the "E-3." Operating differential is the same as on all of maker's standard instruments, namely ± ¼° to ± 25°. Tight-fitting sheet metal cover; cast iron vapor-tight base and cover with gasket available at extra charge. Dimensions: 7¼" × 2¾" × 3½". ("E-3" slightly wider.)—*Burling Instrument Co., 253 Springfield Ave., Newark, N. J.*

Electric Oven for Controlled Aging Tests

New "Hotpack Oven" is a portable electric oven with automatic control of time-temperature test conditions, developed for controlled aging of products requiring a series of temperature changes from room to 180°C., each temperature change to be held automatically for a predetermined period of time. Among features: Thermostatically controlled from room to 180°C., with a sensitivity of ±1°C. Mechanically convected with a sealed-in blower unit, developing 550 c.f.m. requiring no oiling and little maintenance. "Timeostat" automatically controls predetermined temperature and the time cycle, for periods up to 24 hours; will automatically control a time lock on door to prevent interference with operation during aging process; can be manually reset at any point in the operation. With new oven, any number of specific temperatures may be developed and controlled for a specified time to within ±1°C. The fact that heat transfer is by mechanical convection, and not dependent on temperature differentials, permits heat to be transferred speedily; and heating efficiency of cabinet is said to be superior to that produced by gravity convection, permitting increased loading capacity and reducing cost of operation. Construction of oven is of either stainless steel interior or "All-Steel" finished in laboratory grey baked-on enamel exterior. Blower and controls are isolated from the working chamber by being placed in a separate compartment. New ovens may be had in interior sizes ranging from 2.25 ft.³ to 27 ft.³ and are shipped set up and ready for operation.—*The Electric Hotpack Co., Inc., 1225 Cottman St., Fox Chase 11, Penna.*

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Reflex Torque Control by sight, sound and feel—automatically fast, involuntarily accurate.
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Instrument Societies

"Ket" Dinner Speaker at Detroit Conference

Following is the program of the I.S.A. Regional Conference on April 4th in Detroit, at which the Wyandotte and Detroit Sections will be the hosts.

The Conference will be held in the Rackham Memorial Building.

Registration will start at 9:00 a.m. and the first speaker will start at 9:30. It is hoped that all those attending the meeting will register early.

The subjects and speakers are:

Unusual Control Problems, Dr. John Grebe, Physicist, Dow Chemical Company.

Piston Ring Gaging Instruments, Paul Exline, Section Engineer, Gulf Research & Development Company.

Non-Destructive Testing of Materials by Means of Supersonics, Harry Shaper, Manager, Instrument Department, Brush Development Company.

How Special Metals Solved Instrument Problems, Robert Carson, President, Instrument Specialties, Inc.

Instrumentation Problems of the Metals Industry, John R. Green, Manager, Steel Division, Brown Instrument Company.

Diaphragm Control Valves, Bruce Irwin, Hammel-Dahl Co.

Boiler Control, P. S. Dickey, Chief Engineer, Bailey Meter Company.

Flow Rate Metering Enters a New Technical Era, Kermit Fischer, Pres., Fischer & Porter Company.

R. J. S. Pigott, Staff Engr., Gulf Research & Development Co., will act as Toastmaster for the dinner in the evening. Dr. Kettering of the General Motors Research Labs., will be the dinner speaker.

The Delegates from I.S.A. Sections and Representatives from Societies will hold a Business Meeting on Friday, April 5th.

—RICHARD RIMBACH, *Sec'y pro tem*

Program of Panel Sessions Sponsored by the Chicago Section, I.S.A.

To be presented at the Production Show and Conference, Stevens Hotel, Chicago, March 20-21-22, 1946

PANEL NO. 1, (MAR. 20) SUBJECT—MEASUREMENT

Chairman—J. H. Cuthbert, Carnegie-Illinois Steel Corp.

1. *Temperature Measurement.* Speaker—J. C. Peters, Leeds & Northrup Co.

2. *Rapidly Fluctuating Flow Measurement.* Speaker—J. B. McMahon, Republic Flow Meters Corp.

3. *Recording of Electrical Measurement.* Speaker—R. J. Kryter, Esterline-Angus Co., Inc.

PANEL NO. 2 (MAR. 21). SUBJECT—CONTROL

Chairman—H. Barnett, The Powers Regulator Co.

1. *Types of Automatic Controllers Available and Their General Characteristics.* Speaker—A. F. Sperry, Hubbard Engineering Co.

2. *Application of Electrical Types of Automatic Controllers to Industrial Processes.* Speaker—H. C. Frost, Corn Products Refining Co.

3. *Application of Mechanical Types of Automatic Controllers to Industrial Processes.* Speaker—G. G. Gallagher, Universal Oil Products Co.

PANEL NO. 3 (MAR. 22). SUBJECT—WHAT'S NEW IN INSTRUMENTS AND CONTROL.

Chairman—John Vaaler, N. R. K. Mfg. & Engineering Co.

1. *Quality Control of Electrical Components.* Speaker—Richard Schoenfeldt, Wheelco Instruments Co.

2. *Features of the New Republic Boiler Meter.* Speaker—R. A. Ackley, Republic Flow Meters Co.

3. *The New CycleLog.* Speaker—J. J. Connelly, Foxboro Company.

4. *The Veriflow Meter.* Speaker—William Pugsley, The Hays Corp.

5. *Standardized Electronic Units for Process Measurements.* Speaker—C. H. Barnard, Application Engineer, Bailey Meter Co.

6. *The New Electric Input Controller.* Speaker—J. E. Booth, Field Engineer, The Bristol Company.

Each panel will be of approximately two hours' duration and it is the Committee's thought that each speaker should limit himself to 25 minutes. This will leave about 45 minutes for discussion of the various papers. Panel No. 3 will prove an exception to this schedule. Each speaker on this panel will be given approximately 15 minutes.

AKRON

At the second meeting of the Akron Instrument Society (at the Y.W.C.A. on February 8th) approximately sixty members attended and twenty more persons expressed their desire of becoming members by paying the initiation fee. This now brings our total paid group to 84 and we hope that this can be increased.

Mr. Carpenter of the Physical Testing Laboratory of B. F. Goodrich Company gave a very absorbing talk entitled "Professional Status of Instrument People." His talk was really some straight and sound advice and it made a great number of us present give this problem of organization of an instrument society more serious thoughts. Mr. Carpenter presented a very clear picture of the present status of instrument people and why we should get behind an instrument organization. He also pointed out the advantages to be gained by being organized professionally. It was his thoughts that the status and abilities of the people in the instrument field were not fully recognized and that this would only come about by proper organization.

After Mr. Carpenter's talk, Temporary Chairman C. B. Luther requested a report from the Nominating Committee. This committee presented names of Candidates and the election of officers was held. Result:

President, C. B. Luther (Goodrich); *Vice President*, S. T. Wepsic, (Firestone); *Secretary*, Fred Appel, Jr. (Pittsburgh Plate Glass); *Treasurer*, L. H. Smith (Goodrich).

The following permanent committees were appointed:

Lecture: N. C. Reed, C. B. Luther, C. W. Groncy, G. P. Bosomworth.

Program: S. T. Wepsic, E. E. Larson, J. M. Ryan, F. E. Weisend, R. C. Davis, H. J. Levine.

By-Laws: Fred Appel, P. C. Smith, H. H. Deist, J. Markwald, Carl A. Antes, O. Cundiff.

Finance: G. North, R. C. Kelley, D. M. Yoder, M. H. Millar, V. H. Bodine.

Membership: E. R. Eisele, A. H. Richards, K. W. Davies, R. W. Black, J. C. Crum.

Publicity: Fred Mason, E. H. Harris, T. Rowe.

—S. T. WEPSIC, *Vice President*

ATLANTA

The regular monthly meeting of the Georgia Society for Measurement & Control was held in the Blue Flame Room of the Atlanta Gas Light Co. on February 26.

The speaker of the evening was Mr. Milton F. Merl, representative of the Republic Flowmeters Co., who presented a talk on "The Theory and Application of Flowmeters." It was well illustrated by slides showing the details of flowmeters and some of their applications. Questions were asked which brought out several interesting points and the majority of those present indicated that instruments of measurement and control constitute the subject on which we seek the most information.

DETROIT

At the February 18th meeting of the Instrument Society of Detroit, Mr. M. Yeasting of the Toledo Scale Company spoke on "Force, Weight and Torque Measurements." In his illustrated talk Mr. Yeasting mentioned some of the problems involved in scale design, and covered many applications in various fields of measurement and control. During the subsequent discussion, comparative characteristics of scales and of other force indicators were described; also discussed were primary standards of measurement, sources of errors and other items of interest to the audience.

At the March meeting, the question of affiliation with the I.S.A. will be brought to a vote.

—S. KULKA,
Chairman, Publicity Committee

INDIANAPOLIS

The February 5 meeting of the Indianapolis Technical Instrument Society was held at Purdue University Center. At this meeting the following

permanent officers and committees were selected:

President: W. H. Sisson (Brown Instrument Co.); *Vice-President:* J. L. Montgomery (P. R. Mallory Co.); *Sec. Treas:* M. R. Underwood (Indianapolis Power & Light Co.).

Executive Com.: H. R. Rockwell, Jr. (Thomas & Skinner Co.), F. R. Finehout (Meters, Inc.), W. H. Bollinger (Esterline-Angus Co.), D. M. Mead (Diamond Chain Co.), S. F. Mulford (Stewart-Warner Co.).

Program Committee: E. L. Keeler (Eli Lilly), W. R. Baldwin (U. S. Rubber Co.), A. J. Shultz (Naval Ordnance Plant), C. C. Nickel (Indianapolis Power & Light Co.), L. G. Collet (Allison Div. G. M.).

Membership Committee: J. W. Sutton (Electronics Labs.), J. F. Price (R. C. A.), Leon Stewart (Rock Island Refinery), Norman Krone (Stewart-Warner Co.), E. W. Tyler (Indianapolis Power & Light Co.).

After the business meeting, we had four very good War Training Films from the War Department: Aircraft Instruments; Instrument Flight; Booby trap Detection (British Film); Booby-traps: Enemy Types and Effects.

—MORRIS UNDERWOOD, *Sec'y.*

KANSAS CITY, MISSOURI

At the January 29 meeting of the Kansas City Industrial Instrumentation Society, the gavel was turned over to our new president, Lester Johnson of the Sinclair Refining Company and the new officers presided — Bob Cooke of Westinghouse, Vice Pres., and Oliver L. Boutros of the Boutros Instrument Laboratory, Sec'y & Treas.

The Quiz Kids' portion of our program was dispensed with and Mr. Myron M. Clark of T.W.A. presented the A-2 and A-3 Automatic Pilot. The discussion was augmented with films and Mr. Ansel Stubbs of the A. J. Griner Co., who is well versed in the Automatic Pilot, contributed much and the entire membership gained a great deal from the meeting.

At our February 26 meeting Bob Cooke of the Westinghouse Co. presented the new Army Vision Educational films on the general introduction to the study of electrical instruments, "Their Construction, Operation, Selection," Mr. Cooke adopted a scholarly procedure and the group participated in reading the hand books which were given to them by Mr. Cooke.

—OLIVER L. BOUTROS, *Sec'y-Treas.*

LOS ANGELES

At the February 6th meeting of the Los Angeles Section, I.S.A., the speaker was Mr. Clifford Berry, Research Engineer of Consolidated Engineering Corp., Pasadena, California who explained and demonstrated the new Electric Computer which solves as many as 12 complex mathematical equations simultaneously. It can be operated by a girl who can learn its operation details in as short a time as 30 minutes. The makers claim as its advantages, greatly reduced time in calculating results in chemical analyses made by the mass spectrograph and infrared spectograph. Among its applications are the computing problems of the type encountered in aircraft design and other fields of engineering.

The talk was illustrated by slides

AUDIO SIGNAL SYNCHRONIZER—
MODEL J for
Synchronization of Audio Frequencies

This instrument is essentially a dual input, sensitive vacuum tube voltmeter. In production and laboratory test procedures, typical applications are: synchronizing audio oscillators with radio WWV, calibrating modulation frequencies of transmitters, adjusting filter networks and tuned circuits —or any application where a beat must be observed down to a few cycles per second.

The usual procedure with cathode ray techniques requires considerable time for interpretation of frequency differences. The Model J will synchronize and give direct indication of frequency differences as low as one beat in 24 hours. The gain of each input, for full scale deflection on the meter, exceeds 60 D. B.

Input impedence is 500,000 ohms over the audio spectrum and is constant at any setting of the input attenuators. The inputs are isolated from each other and have no electrical effect on the signal mix. A jack is provided so that the output synchronized signal may be used to drive an oscilloscope.

Dimensions—19" L x 8-¾" H x 9-½" D
Furnished in oak cabinet if relay rack mounting is not desired.

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INSTRUMENT SOCIETIES CALENDAR

City, Society, and Secretary	Date and Place	Subject and Speaker
Akron, Ohio; Akron Instrument Society; S. T. Wepsic, Firestone Tire & Rubber Co.		
Atlanta, Ga.; Georgia Society for Measurement and Control; John Roberts, 439 Deering Rd.	**Mar. 25**[A], Blue Flame Room, Atlanta Gas Light Co.	"The Story of the Bellows," J. Harvey Seat
Baltimore, Md.; Baltimore Industrial Instrumentation Society; F. Ragan, Fuel Div., Beth. Steel, Sparrows Pt., Md.	Engineers Club, 6 W. Fayette St.	
Charleston, W. Va.; Charleston Section, I.S.A.; M. B. Lorig, 1506 Virginia St., Charleston 1	**Apr. 1**[B], Same **May 6**[B], Same	"Control Valves," Bruce Irwin, Hammel-Dahl "Pneumatic Transmission and Control," W. B. Heinz, Cochrane Corp.
Chicago, Ill.; Chicago Section, I.S.A.; A. J. Butler, c/o IHC, 2626 W. 31st Blvd., Chicago	**Apr. 1**[B], To be announced **May 6**[B], To be announced	"Application of Valves in Automatic Control," C. E. Mason, Bristol Co. "New Electronic Measuring Instruments," H. C. Rowe, Rowe Radio Res. Lab.
Cleveland, Ohio; Cleveland Instrumentation Society; A. J. McCullough, Minneapolis-Honeywell, 5005 Euclid Ave., Cleveland 3		
Detroit, Mich.; Instrument Society of Detroit; J. McCullough, 870 Seward St., Detroit 2	**Mar. 18**[B], Ethyl Research Lab. **Apr. 4, 5, 6,** Rackham Memorial Bldg.	"Automatic Electronic Controls," G. Volkenant, Minneapolis-Honeywell I.S.A. Spring Technical Session and Delegates Business Meeting
Florence, Ala.; Muscle Shoals Instrument Society; J. W. Moffett, 323 E. Mobile St., Florence		
Ft. Worth, Tex.; Ft. Worth Electronics Club; W. H. Farrington		
Gulf Coast (Tex.); Gulf Coast Section, I.S.A.; O. D. Sanders, Neches Butane Co., Port Neches, Texas	**Mar. 19,** Fuller's Drive-In **Apr. 16,** Lamar College	To be announced, C. D. Peterson, Fisher Governor "The Smith Meter," J. W. Harris, Smith Meter Co.
Hartford, Conn.; Hartford Society for Measurement & Control; Gustave L. Manke, c/o Veeder-Root, Sargent & Garden Sts.	**Mar. 19**[B], Bond Hotel **Apr. 16**[B], Same **May 21**[B], Same	"Electron Microscope," R. B. Barnes, C. J. Burton, Amer. Cyanamid "Comparison of Materials for Gages," H. O. Richter, W. R. Moore, Norton Co. Annual Business Meeting
Houston, Tex.; Houston Instrument Society; O. W. Muller, 1536 Mellie Esperson Bldg., Houston 2		
Indianapolis, Ind.; Indianapolis Technical Instrument Society; Morris Underwood, Indianapolis Power & Light Co., Indianapolis 6	**Mar. 5,** Purdue University Center **Apr. 2,** Same	"Diaphragms and Control Valves," P. A. Elfers, Fisher Governor "Recording Instruments," R. J. Kryter, Esterline-Angus
Kansas City, Mo.; Kansas City Section, I.S.A.; O. L. Boutros, 1627 E. 31st St., Kansas City 3	**Mar. 26**[E], Kansas City University	"Electronics," W. A. Reichow, Minneapolis-Honeywell
Los Angeles, Calif.; California Section, I.S.A.; M. D. Pugh, 35 S. Raymond Ave., Pasadena 1	**Apr. 2**[B], Eaton's Ardmore Cafe **May 7**[B], Same **June 4**[B], Same	To be announced To be announced To be announced
Newark, N. J.; Society for Measurement & Control (N. J.); H. S. Close, 831 Dixie La., Plainfield, N. J.	**Mar. 5**[B], Essex House **Apr. 2**[B], Same	"Combustion Control," Harry R. Kessler, Republic Flow Meter "Thermocouple Method of Temp. Meas.," V. L. Parsegian, Tagliabue
New Orleans, La.; New Orleans Instrument Society; W. H. Haney, 1016 Esplanade Ave., New Orleans	St. Charles Hotel	
New York, N. Y.; New York Section, I.S.A.; C. D. Corey, Rieber Research Lab., 127 E. 73rd Street, New York 21	**Mar. 25**[B], Men's Faculty Club	"What Price Instrument Research," Chas. H. Colvin
N. Indiana; North Indiana Section, I.S.A.; C. P. Haynes, Red River Oil Ref., 935 177th Pl., Hammond, Ind.	**Mar. 15**[B], Hotel Gary	"Electronics," Theodore Cohen, Taco Eng. Co.
Philadelphia, Pa.; Philadelphia Section, I.S.A.; Clarence W. Wood, Mason-Neilan, 6908 Market St., Upper Darby, Pa.		
Pittsburgh, Pa.; Pittsburgh Section, I.S.A.; L. M. Susany, c/o Carnegie Institute, 4400 Forbes St.	**Mar. 25**[B], Roosevelt Hotel **Apr. 22**[B], Same **May 27**[B], Same	"Inst. Maintenance in Oil Refinery," M. H. White, Atlantic Ref. Co. "Control Valve Characteristics," R. Rockwell, Mason-Neilan "Fractional H-p. Motors," C. G. Veinott, Westinghouse
St. Louis, Mo; Saint Louis Section, I.S.A.; H. E. Zeffren, 5625 Enright Blvd., St. Louis 12	**Mar. 25**[C], York Hotel **Apr. 29**[C], York Hotel	"Control Valve Flow Characteristics," R. Rockwell, Mason Neilan "New Developments in Manometers," A. A. Hejduk, Meriam Instr. Co.
Sarnia, Ont., Canada; Sarnia Instrument Association; K. Williamson, 168 Cobden St., Sarnia		
Southwest Texas; South Texas Instrument Society; Homer C. Givens, LaGloria Corp., Falfurrias, Tex.		
Kingsport, Tenn.; Tennessee Section, I.S.A.; C. F. Palmer, 2924 J. C. Hwy., Kingsport	**Mar. 13**[C], Kingsport Inn **Apr. 10**[C], Same	"Flow Metering," J. B. McMahon, Republic Flow Meters "Electrical Instruments," L. F. Parachini, Weston
Toronto, Ont., Canada; Ontario Section, I.S.A.; T. C. Agnew, Minneapolis-Honeywell	**Apr. 18**[B], Chez Paree Rest.	"Instrumentation in Glass Industry," W. O. Fleming, Corning Glass (Canada)
Washington, D. C.; Washington Section, I.S.A.; G. M. Rolls, c/o American Instrument Co., 8010-8020 Georgia Ave., Silver Springs, Md.	**Mar. 19**[D], Interior Dept. Auditorium	"Automatic Weather Stations," Louvan E. Wood; "Radio Sondes," Vernon D. Hauck
Whiting, Ind.; Whiting Instrument Men's Guild; Fred T. Lucas, 1713 Myrtle Ave., Whiting, Ind.		
Wyandotte, Mich; Wayne County Section, I.S.A.; Chas. Chessrown, P. O. Box 150, Wyandotte	**Mar. 25**[E], Presbyterian Church, Wyandotte	"Custom Calibrated Aneroid Instruments," L. E. Demler, Wallace & Tiernan

[A] Meeting at 7:30, no dinner [B] Dinner at 6:30, meeting at 8 [C] Dinner at 7, meeting at 8 [D] Meeting at 8, no dinner [E] Dinner at 6:30, meeting at 7:30

and a demonstration of the computer was given following the talk.

About fifty were present at the meeting. —M. D. PUGH, *Secretary*

NEWARK

The February meeting of the New Jersey Section of the I.S.A. was an open forum of questions and answers. The technical chairman, Mr. H. F. Moore, had a relatively easy time since questions and answers flowed freely without prompting. In fact the debates were so lively that only six or seven questions could be answered before adjournment time was reached. After adjournment, small groups continued to discuss the questions raised in the meeting.

The ice of formality was shattered at the outset by the treatment accorded Walt Maurer's question, and from that point on practically everyone joined the friendly battle. The sixty members and guests present constituted an active group of participants, in contrast to some meetings in which those present are mainly listeners!

The discussions centered around the following subjects: (1) Static head corrections for the various types of filled-tube temperature systems (2) Measurement of interface level with narrow gravity separation; (3) Source and correction of "howling" in a pressure-reducing valve; (4) Is there need for calibration of proportional-band and reset-rate dials or settings of pneumatic controllers? (you should have heard this discussion!); (5) Proper leakage requirements of double seated control valves; (6) How to choose plug characteristic for a control valve application; and (7) Rangeability requirements of control valves.

At the intermission, President Roberts reported the latest news from I.S.A headquarters. His membership report indicated that 50% of the members have already paid their 1946 dues, including the National Office portion.

—BOB GRAY

NEW YORK

The Annual Meeting of the New York Section of the I.S.A., on January 28 at the Men's Faculty Club, Columbia University, opened at 8:00 p. m. The minutes of the previous meeting were read and approved.

The Treasurer's report showed a slight net increase in membership to 132 persons. The financial balance gained slightly over the previous year. The Treasurer also explained the $10.00 bill for dues as cost of the society joining the national organization. The Treasurer was given a vote of thanks for his report.

The President then read a report from the Secretary of National, indicating that eleven locals have ratified the national constitution. The next order of business being election of officers, a motion was made and passed that the Secretary cast one ballot for the officers nominated at the December meeting.

The President then appointed as tellers for the Executive Committee E. R. Manning, R. E. Tarring and W. C. Bellis. They reported a tie for the fifth member of the Executive Committee. A show of hands while the contestants were out of the room completed the Executive Committee, as follows: Harry E. Geddes, Ralph Batcher, V. L.

"The whole is equal to the sum of all its parts"—Elementary? Of course—as simple and unchanging as all great principles. This axiom is a fundamental manufacturing creed at Stancor. We know the established excellence of Stancor Transformers is vitally dependent upon the perfection of each successive manufacturing step—from engineering considerations of individual specifications—through coil-winding, laminating, assembling, finishing, testing—and, finally, to careful packing for shipment.

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Parsegian, Lt. Comdr. H. R. Kalbfleisch, E. B. Schofield.

Mr. Ed Smith announced a lecture on Transient Response at the A.S.M.E. for February 26, 1946 at the Engineering Societies Building.

The chairman of the committe, H. O. Nilsson, introduced Mr. Robert B. Darling, who gave an interesting talk on Instrument Motors. The talk was followed by a lively discussion with the meeting concluding at 10:15 p. m.

The February 1946 meeting of the I.S.A., New York Section, was held at the Men's Faculty Club, Columbia University, with about thirty-six attending supper and about ten arriving later. The meeting opened at 8:00 p. m. with the minimum of formal business and was then turned over to Mr. Ed Smith, as Technical Chairman for the evening. He introduced Dr. Leroy A. MacColl of the Murray Hill Laboratory, Bell Telephone Laboratories, Inc., who gave an interesting paper on the Modern Methods for the Theoretical Study of Problems of Automatic Control and Regulation. After a discussion at the conclusion of the paper, the meeting was adjourned at 10:15 p. m.

—CHAS. D. COREY, *Sec'y*

PHILADELPHIA

The February meeting of the Philadelphia Section enjoyed its customarily large attendance, ninety-five being present.

President Jack Johnston announced that the Philadelphia evening classes on Instrumentation were under way. Also mentioned was Vice-President Trapnell's talk on "Instrumentation in Plant Design" which is to be delivered March 5th at an ASME meeting at the University of Pennsylvania.

As an innovation, a short talking picture entitled "Fisherman's Paradise" was shown.

The meeting featured a very interesting talk entitled "Behind the Instrument Dial" by Mr. Lawrence F. Parachini of the Weston Electrical Instrument Corporation. After some mention of the less important types of electrical instruments such as the hot-wire ammeter and electrostatic voltmeter, Mr. Parachini launched into a clean-cut discourse on the main types of electrical instruments, their sensitivities, basic designs, general applications and limitations. The types covered were: The moving-iron, electrodynamometer, permanent-magnet, permanent magnet used with rectifiers for a.c. measurement, and the hot-wire thermocouple type used for high-frequency applications.

For demonstration, there was on hand a model of every type mentioned and many more variations of the same.

Refreshments were served at the meeting's conclusion.

—JOHN J. FREGEAU,
Chairman Publicity Committee

PITTSBURGH

The February meeting of the Pittsburgh Section of the I.S.A. was held Monday the 27th at the Roosevelt Hotel. Approximately forty members and guests were present for the dinner. Of these, five were from Cumberland, Md., three from Meadville, Penna., and one from Chicago. One hundred and nine were present for the meeting.

Secretary Rimbach of the I.S.A. announced a Board of Directors meeting will be held April 4th and 5th in Detroit. Al Shaffer was unanimously elected as the delegate to represent the Pittsburgh Section. The Detroit and Wyandotte Sections will be hosts to the delegates and visitors at this meeting.

Lyman H. Allen, of the American Viscose Corporation, spoke on the subject "Experimental Studies in Fractionating Column Control", which he illustrated with slides. He described applications of instruments for the control of the several variables which may disturb equilibrium in fractionating columns. As pointed out, although some applications were unique, they were affective. Inasmuch as Mr. Allen's subject was of interest to many persons present a lively discussion followed.

—LESTER F. BOSS,
Member Meetings Committee.

SAINT LOUIS

The St. Louis Section of the I.S.A. held its regular meeting at the York Hotel on January 29. The program for payment of dues until May 31, when the current dues year of the local expires, was explained by Chairman Boyle. On that date, the collection of dues will be turned over to the National Society.

A number of the membership application forms sent out by the National were distributed, and a number of applications were received.

The speaker of the evening was Mr. David M. Boyd, Jr., Chemical Engineer of the Monsanto Chemical Co., St. Louis, who spoke on "Fractionating Column Control." A condensation of the talk follows:

"Fundamentally the problem of controlling a fractionation column is one of maintaining a material balance. All of the instruments applied to the column should be used to this end.

"The material balance is maintained by controlling the heat to the column. The flow of heat to the column is controlled by a temperature controller. The rest of the instrumentation is designed to either follow the action of this controller, or to make its job easier. The temperature controller is inherently a slow acting instrument as compared to pressure, flow, etc. and therefore should be protected from upsets as much as possible. This is done by keeping the reflux to the column at a constant ratio, and keeping the feed nearly so by using a pneumatic set flow controller.

"There are three fundamental types of continuous fractionation control problems, each will require a typical system of control for optimum results. The three types of control systems are as follows: (1) Stripping section control; (2) Rectification section control; (3) Material balance control.

"It is necessary to make a thorough analysis of the fractionation problem involved before choosing the correct control system."

—H. E. ZEFFREN, *Sec'y.*

WASHINGTON

The nineteenth meeting of the Washington Section, I.S.A., was held in the U.S. Interior Dept. Auditorium on February 26th.

After a few short announcements, the floor was given to Dr. Dean A. Lyon, consultant on evaporated films, who gave a very interesting and informative talk on methods and use of non-metallic coatings on optics for reducing or increasing reflection.

The principal speaker of the evening was Mr. L. F. Parachini of Weston Electrical Instrument Corp., on the subject: "Behind The Instrument Dial." Samples of various instruments were passed out to the group for inspection during the talk.

Considerable post-meeting interest was shown in regard to both talks, as evidenced by the number of people remaining to ask questions and inspect samples on display.

—G. M. ROLLS, *Corresp. Sec'y.*

WAYNE COUNTY, MICH.

The Wayne County Section I.S.A., had a very successful meeting on Feb. 24. There were several visitors from the Detroit Section and a number of local visitors, some of whom are becoming members.

The slides and discussions presented by Mr. Gambrill of Moore Products and Mr. Lupton of Fischer & Porter, assisted by Mr. Henry of Fisher Governor Co., were very helpful and there were many questions about rotameters and flow control, valve positioners, and diaphragm valve characteristics, etc.

Much interest was shown in the coming I.S.A. convention. Several of us are working with Detroit members on committees and we want to make this first convention one of the biggest and best.

—JOHN MACPHERSON, *Vice President*

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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on page 197.

N-69 **Reflectoscope.** 4-page 8½" × 11" Bulletin 300 pictures and describes the "Supersonic Reflectoscope," an instrument for the non-destructive testing of materials for internal defects; includes principle of operation, method of operation, list of testable materials; shows appearance of oscilloscope screen at time of testing a billet. Sperry Products, Inc., Hoboken, N. J.

N-70 **"Opti-Locator."** 4-page 8½" × 11" bulletin No. 451 describes and illustrates diagrammatically and photographically applications of this instrument for locating, centering and measuring. By locating and aligning axis of a revolving spindle with any desired point on the workpiece, measuring, milling, drilling, boring or facing operations can be performed with high precision. The Benton Co., 351 South La Brea Avenue, Los Angeles 36, California.

N-71 **Short-range pH Papers.** 6-page 3" × 6" folder introduces the new short-range "Hydrion" pH papers 1-14. Accuracy can be determined to 0.25 pH units. Also shown is the convenient transparent plastic dispenser which protects the paper. R. P. Cargille, 118 Liberty Street, New York 6, New York.

N-72 **The G-Meter.** 2-page 8½" × 11" bulletin illustrates and describes the Schottland G-Meter for the measurement of the maximum instantaneous shock in terms of G (gravitational) units. Frederic D. Schottland, 82-62 Grenfell Ave., Kew Gardens, N. Y.

N-73 **Pacitor Gauge.** 12-page 8½" × 11"bulletin describes and illustrates an electronic instrument for measuring aircraft fuel and other liquids. Accuracy of fuel measurement is within 3% and remains constant regardless of extreme changes in flight altitude, or in temperature. Simmonds Aerocessories, Inc., 30 Rockefeller Plaza, New York 20, New York.

N-74 **Pyrometers.** 2-page 8½" × 11" bulletin pictures and describes "Xactemp" pyrometers. for temperature readings of non-ferrous molten metal. Consists of thermocouple with 43" stainless steel extension, and indicator with scale starting at 50, thus allowing rapid movement of indicator to follow the most sensitive thermocouple. Claud S. Gordon Company, Indianapolis, Indiana.

N-75 **Combination Air Separator and Trap.** 4-page 8½" × 11" Bulletin S-13 describes, pictures and illustrates applications of the "Airfuge" for positive compressed air cleaning. The Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio.

N-76 **Stereograph.** 4-page 8½" × 11" bulletin illustrates and describes the "Pomeroy Stereograph," a self-contained perspective drawing machine for the production of a stereo-perspective pair of drawings which can be viewed as a synthetic reality in space. Complete illustrations of the principle are given. Pomeroy Stereograph Company, Inc., 1783 East 11th Street, Cleveland 14, Ohio.

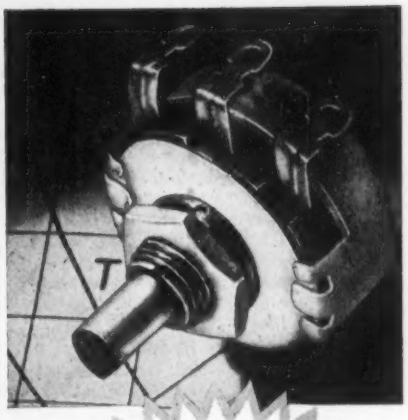
N-77 **Glass-working Lathe.** 24-page 8½" × 11" bulletin describes and pictures the development of the glass working lathe through the necessity for precision in glass work in connection with the construction of the company's line of power type vacuum tubes. The bulletin also contains a complete description of a vertical sealing machine, a precision spot-welder and several models of oil vapor vacuum pumps. Litton Engineering Laboratories, Redwood City, California.

N-78 **Optical Pyrometer.** 6-page 8½" × 11" bulletin describes and illustrates the "Pyro" optical pyrometer, an entirely self-contained instrument for measuring high temperatures, based on the principle of the radiation of light. Complete instructions for operating are given as well as directions for maintenance. The Pyrometer Instrument Co., 103-105 Lafayette Street, New York, N. Y.

N-79 **Indicating Micrometer.** 4-page 8½" × 11" bulletin describes and photographically illustrates the "Federal" indicating micrometer which combines the precision of the dial indicator for uniformity of contact pressure, and for use as a comparator gage, with the accuracy of the micrometer screw for measuring. Various types of dial indicator snap gages are also shown. Federal Products Corporation, 1144 Eddy Street, Providence 1, Rhode Island.

N-80 **Electronic Pneumatic Mechanical Instrumentation.** 32-page 8½" × 11½" Jan.-Feb. issue of this house organ contains the following articles: "A New Era in Pyrometry" by C. A. Vogelsang, "Automatic-control Terminology" by D. P. Eckman, "Significance of Design in Motorized Control Valves of the Sliding-stem Type" by S. D. Ross, "Instrumentation of Dough and Proof Rooms" by L. E. Cuckler and R. E. Jones, "Instrumentation of Annealing Furnaces" by J. P. Vollrath and "Oil Refinery Instrument Maintenance" by Alfred Krieg. Brown Instrument Company, Wayne and Roberts Avenues, Philadelphia 44, Penna.

N-81 **Testing Machines.** 8-page 8½" ×11" bulletin describes and illustrates instruments for precision measurement of impact, tension, compression, transverse and hardness. Featured are the hydraulic testing machines for capacities to 300,000 lbs. Riehle Testing



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N-82 **"The Proximity Fuze."** 8-page 6" × 9" booklet presents the story of Cornell-Dubilier's capacitors' part in this vital secret weapon. The purpose of this fuze is to "feel out" or sense when a shell is near enough to its target to cause damage and then explode it. It is stated that the success of this fuze depended upon the successful development of capacitors physically smaller, more rugged, and of greater electrical stability than anything previously conceived. Cornell-Dubilier Electric Corp., South Plainfield, New Jersey.

N-83 **"Apparatus Headliners."** 4-page 8½ × 11" issue of this house organ describes and illustrates the Hoskins line of combustion tube furnaces, crucible furnaces, muffle furnaces, heat treating furnaces for NE steels, and hot plates. Complete specifications are given for all models. Boder Scientific Company, 907-909 Penn Ave., Pittsburgh 22, Pa.

N-84 **"Electro Counter."** 4-page 8½" × 11" bulletin describes and illustrates an electronic device that counts parts produced on any motor-driven machine and makes an accurate tamper-proof record of total number of pieces, time required to make each piece, machine down time and number of pieces per minute, per hour, per day. Counter is located at machine while recorder may be located in Production Superintendent's office. Lansing Engineering Company, 934-36 Clark St., Lansing 6, Michigan.

N-85 **Surface Plate Inspection.** 4-page 8½" × 11" bulletin describes and illustrates the "Pla-Chek" for surface plate inspection: a hardened steel bar with 12 steps spaced exactly 1" apart; a micrometer screw thread ground on the lower end; a large micrometer thimble graduated in 0.0001" on upper end of bar and a triangular-shaped bracket for rigid support. Measurements are guaranteed accurate to 0.00005" for any size from 0.001" to 12" from surface of plate. Cadillac Gage Company, 20316 Hoover Road, Detroit 5, Michigan.

N-86 **Interference Viewer.** 6-page 8½" × 11" bulletin describes and illustrates an instrument which brings convenience and uniformity to optical interference measurements. The surface being examined (for flatness or for size) is both illuminated and viewed on a line perpendicular to the surface. The principle is fully explained by text and diagrams; instructions are given on identification of deviations from flatness, determination of parallelism of an unknown gage block, and determination of the size of an unknown gage block. The Optron Laboratory, 2655 Salem Avenue, Dayton 6, Ohio.

N-87 **"Instruments and Controllers in Industry."** 24-page 8½" × 11" Bulletin 46-713 covers indicating and recording instruments and automatic controllers for a wide variety of industrial applications where suction, pressure, flow, speed, liquid level and density are to be indicated, recorded and/or controlled. In addition to describing the company's many instruments, the booklet outlines their most common uses in connection with industrial control problems such as: (1) pressure reducing control; (2) pressure relief or back pressure control; (3) rate-of-flow control; (4) liquid level control; (5) liquid density control; (6) turbine driven compressor pressure and suction control; (7) speed control. Hook-up diagrams accompany each use. The Hays Corporation, Michigan City, Ind.

N-88 **Combustion Equipment for Steel Mills.** 4-page 8½" × 11" bulletin gives six reasons why steel mills require this company's combustion equipment: Photographic illustrations show applications of the instruments for billet heating furnace, sintering machine, ingot heating furnace, slab heating furnace and wire annealing furnace. The North American Manufacturing Co., Cleveland 4, Ohio.

N-89 **Induction Heating.** 24-page 8½" × 11" booklet illustrates and describes the two general classifications for induction heating equipment: units that heat treat metal surfaces either internally or externally or both; and units that through-heat metals for such hot working operations as forging, upsetting, hot heading, swaging, extruding, brazing, annealing, etc. Text covers application of heat treatment, advantages of the induction method and type of work produced. Numerous photographs of treated and forged parts serve as a guide to other treating and forging problems. Budd Wheel Company, Induction Heating Division, Detroit 14, Michigan.

N-90 **Photelometer.** 4-page 8½" × 11" Bulletin 103 illustrates and describes this instrument for rapid and accurate chemical analysis. The Photelometer is simple to use and is easily standardized by reading the transmittances of a number of solutions having predetermined concentrations prepared in accordance with a specific chemical procedure. Accessories required for the instrument are also shown. Central Scientific Company, Chicago, Illinois.

N-91 **Testing Machines and Instruments.** 4-page 8½" × 11" bulletin describes the company's thirty years of experience in the manufacture of Brinell hardness testing machines. The various models are photographically illustrated and described. Other types of testing machines shown include two models of ducility machines for testing drawing qualities and a Universal testing machine. Steel City Testing Laboratory, 8843 Livernois Avenue, Detroit 4, Michigan.

N-92 **"Comparoscope."** 4-page 8½" × 11" bulletin describes and pictures this dual microscope, equipped with a master-stage and a base with an adjustable stage, whereby it is possible to view and compare two surfaces simultaneously. The degrees of roughness are pictured and classified according to standards being established. The Compar-Instrument Company, 16179 Hamilton Avenue, Detroit 3, Michigan.

N-93 **Functional Photography.** 20-page 4¾" × 5¾" booklet shows the way to new and faster methods by recording and reproducing information, much of which is beyond the ability of human vision. The applications described and pictured are radiography, photo layout on metal, ultra-speed photography, photo-visuals, spectroscopy, photo-micrography, electron micrography, micro-radiography, x-ray diffraction, stress analysis, instrument recording, document copying, and Recordak. Eastman Kodak Company, Rochester 4, N. Y.

N-94 **"Cyclograph."** 16-page 8½" × 11" booklet describes an electronic method of conducting non-destructive metallurgical examinations for production-quality control. By glancing at the cyclogram on the cathode-ray screen, an average semi-skilled worker can determine whether or not the sample possesses a desired metallurgical characteristic such as case depth, depth of decarburization, amount of cold work, brittleness (stress gradients) and structure. Bars, rods or sheets may be sorted according to chemical analysis, heat treatment, structure, internal stress, and thickness of plating or cladding. Illustrations and text describes the operation of the instrument. Allen B. Du Mont Laboratories, Inc., Passaic, New Jersey.

N-95 **Isothermal Heat Treating.** 14-page 8½" × 11" booklet covers cyanamid salts for heating and quenching features an article by F. R. Morral, reprinted from "Metal Progress," October 1945, on Heat Treating diagrams—S or TTT curves. American Cyanamid & Chemical Corporation, 3, Rockefeller Plaza, New York 20, N. Y.

N-96 **"Faxfilm."** 8-page 7½" × 9" bulletin describes and shows the results obtained from the use of this method of obtaining a permanent record of every surface studied. Some of the materials for which results are shown are crystals, metals, textiles, paper minerals, and wire cloth. Method can be used to show roughness, waviness, lay, chatter, surface flaws and weave. The Faxfilm Company, 1220 West 6th Street, Cleveland 13, Ohio.

N-97 **Direct-inking Magnetic Oscillographs.** 4-page 8½" × 11" bulletin describes and pictures this instrument

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which, combined with accessory pick-up equipment, records strains, pressures, vibrations, temperatures, light intensity, displacement, current and voltages, phase relationship, counting, surface roughness, acceleration and deceleration, and inertia. The Brush Development Company, 3405 Perkins Avenue, Cleveland 14, Ohio.

N-98 **Combustion Equipment for Heat Treating Plants.** 4-page 8½" × 11" bulletin describes and illustrates equipment required by combustion units in heat treating plants: gas burners, oil burners, turbo blowers, adjustable port valves, "Ratiotrols," "Sensitrols" and safety valves. Applications are shown on a carburizing furnace, Lindberg cyclone furnace, rotary hearth heat treating furnace, radiant ring continuous heat treating furnace, semi-muffle heat treating furnace, pot-type heat treating furnace and car type annealing furnace. The North American Manufacturing Co., Cleveland 4, Ohio.

N-99 **Triple-function Proportioning Control.** 8-page 8½" × 11" bulletin G-15-1 describes an instrument developed for automatic control of industrial process involving time lag. The complete system consists of a primary measuring element, a detecting relay and a "Beck" triple-function mechanism with suitable valve, variable transformer, rheostat, or other device for regulation. Harold Beck Company, Philadelphia 40, Pa.

N-100 **Brinell Manually-operated Testing Machine.** 2-page 8½" × 11" bulletin describes and pictures Brinell hardness tester of the manually-operated bench type, designed to meet the requirements of the smaller shops, heat-treat plants, laboratories, schools, etc. Described also are standard equipments furnished machine: flat anvil, vee anvil and a standard Brinell microscope with micrometer scale. Steel City Testing Laboratory, 8843 Livernois, Detroit 4, Michigan.

N-101 **"General Radio Experimenter."** 8-page 6" × 9" issue Vol. XX Nos. 6 and 7 of this house organ has two feature articles: "An Improved Megohmmeter for A-c. Operation," and "An Analyzer for Vibration Measurements." General Radio Company, 275 Massachusetts Avenue, Cambridge 39, Mass.

N-102 **"Tomorrow's Production Needs Today."** 8½" × 11" broadside unfolds to a single 21" × 23" sheet upon which are pictured many items of measuring instruments and controls. The chart is divided into three sections: (1) primary elements for temperature, combustion, pressure, speed, flow, gas analysis, humidity, smoke density, electrolytic conductivity, acidity, electrical magnitudes; (2) measuring instruments to measure by hand, to indicate automatically, to indicate and record automatically, to control—no index or record, to control—also indicate, to control—also indicate and record, and specialized control systems: (3) signals and controls to signal, to alarm, remote indicators, two-position control, "Micromax" electric control, drive mechanisms, program controls, "Micromax" pneumatic controls, milk-of-lime feeder. Leeds & Northrup Company, 4904 Stenton Avenue, Philadelphia 44, Pa.

N-103 **Inspection Equipment for Internal and External Dimension.** 32-page 8½" × 11" Bulletin 600-1-45 covers

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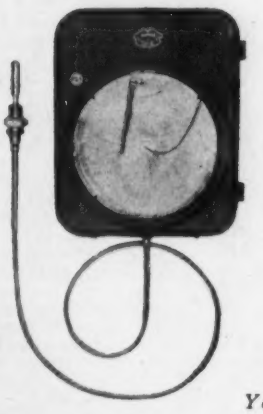

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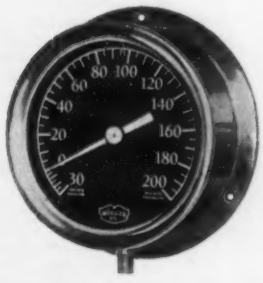

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